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Resource materials to be used in conjunction with the Grade 10 Biology I course outline for the senior high school are presented. A greater amount of material is included than could be used in the alloted time for the course. The teachers can use their own discretion in choosing the materials to be covered, and they can adapt these materials to the particular abilities of each class.

Each unit contains directions on use, a content outline, a textbook reference summary, a master materials list, and estimated teaching time. The four units presented are: Foundations of Life - an Overview, Chemical Background, Origin of Life, and Modern Concept of a Cell; Variety of Life - Basis for Organization, Organization of Living Things, Variety in Animals, and Variety in Plants; Distribution of Life and Change and Continuity of Life - the Continuity of Life, Patterns in Heredity, and Changes in Living Things. Charts and drawings are included.

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BIOLOGY 1

RESOURCE UNIT

UNIT ONE: FOUNDATIONS OF LIFE

Educational Materials Laboratory
Office of Education
JUN 1965
DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

LOS ANGELES CITY SCHOOLS
Curriculum Branch
1963

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Secondary Curriculum Coordinator

AVERILL M. CHAPMAN
Administrator of Curriculum

UNIT ONE: FOUNDATIONS OF LIFE

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UNIT ONE: FOUNDATIONS OF LIFE

USE OF THE RESOURCE UNIT

This resource unit has been prepared and developed for use by biology teachers in Los Angeles City Schools. It is intended that this resource unit be filed in a three-hole loose leaf binder by the teacher. It is hoped that this unbound material will be of greater use to the teacher and will be more adaptable to making changes in sequence and providing for additions and deletions.

The Outline Course of Study for Biology 1, publication SC 597 contains general information vital to the teaching program and should be referred to often. General safety regulations, teaching patterns, and point of view are some of the important sections of this publication. The teacher will find it helpful to use both the Outline Course of Study and the Resource Unit. The Outline Course of Study is available from the Curriculum Branch.

How To Use The Resource Unit

Outline of Content

The teacher should briefly review the pages of this section to receive an over-all view of the entire unit content.

Estimated Time Block

After reviewing the outline of content for this unit, the teacher should make note of the suggested time allotment. The teacher should be encouraged to prepare a block of squares showing the four, five or six week period and plan his own pattern of time allotment for subject matter. The teacher need follow only the estimated time block.

Concepts to Consider

Read the concepts to consider at the beginning of this unit. These concepts are major generalizations of subject content and should serve as guidelines for instruction.

Teaching Approach (Methods and Activities)

The teacher will find this section to be a suggested direction or path for instruction. The approach is sequential and may be used at the discretion of the teacher. It will be noted that there are many more suggestions for teaching than can be carried out for a particular time block. The teacher is charged with the responsibility of selecting those activities best suited to the ability level of his students.

Depth Probe

This section provides three general levels of ability for slow students, average students, and more able students. The teacher may use any or all of these activities. An attempt has been made to alert the teacher to activities that are basic to the subject content. Note that terms such as "optional" or "basic" have been used in this respect. All activities to be done will be decided upon by the individual teacher according to materials and student abilities irregardless of established color code.

"Tools" for Extending Concepts

This section is intended to supply the teacher with enrichment ideas for highly motivated students. Remember that many more ideas have been given than can possibly be carried on, so select those activities that are most suitable.

Planning Ahead

This section is intended to alert the teacher to materials needed for activities coming in following sections of this unit and other units. Pay particular attention to this section on ordering materials from the Science Center, since a two-week-in-advance-order is necessary for many of the fresh materials.

Broadening "Content Horizons"

This section is divided into three parts. The first part is an area devoted to references to be used by the teacher to gain a broader background for subject content. The second part is an area devoted to references to be used for students and care has been taken in recommending those books that are generally found in school libraries. The third part is an area devoted to the textbook reading assignments for the particular subject content. The two textbooks cited are Smith, Ella Thea Exploring Biology 4th and 5th Editions; and Moon, Otto, and Towle Modern Biology, 1960 and 1963 Editions.

UNIT ONE: FOUNDATIONS OF LIFE

CONTENT OUTLINE

I. **Overview**

- A. Living vs. Nonliving
- B. Review of Matter and Energy

II. **Chemical Background**

- A. Submicroscopic Behavior of Particles in Atoms
- B. Structure of Molecules
- C. Chemical Bonding
- D. Structural Formulas

III. **Origin of Life**

- A. Theories
    - 1. Cosmozoic ("dust particles" carrying spores)
    - 2. Heterotroph Hypothesis (protein aggregates)
    - 3. Spontaneous Generation
        - a. Redi
        - b. Spallanzani
        - c. Pasteur
    - 4. Cell Doctrine
        - a. Schleiden
        - b. Schwann
        - c. Virchow

5. Microscope reveals that a "cell is a cell is a cell..."
    a. Leeuwenhoek
    b. Hooke
    c. As a laboratory technique (Use of the microscope)

B. Units of Life (Protists)
  1. Virus
    a. Basic Characteristics
    b. Recent Information
    c. Distribution
  2. Rickettsial Organisms
    a. Basic Characteristics
    b. Recent Information
    c. Distribution
  3. Bacteria
    a. Basis for Identification
      (1) Shape
      (2) Others
    b. Basic Characteristics
    c. Recent Information
    d. Distribution
    e. Feeding
      (1) Autotrophs
      (2) Heterotrophs

            - f. Oxygen Consumption
                - (1) Aerobic
                - (2) Anerobic
            - g. Bacteria and the Nitrogen Cycle
            - h. Bacteria and Disease
        - 4. Blue-Green Algae
            - a. Basic Characteristics
            - b. Distribution
        - 5. Slime Molds
            - a. Basic Characteristics
            - b. Distribution
        - 6. Protozoa (Animal-like Protists)
            - a. Amazing Varieties and Complexities
            - b. Basis for Identification (Basic Characteristics)
                - (1) Ameba and Kin
                - (2) Ciliates
                - (3) Sporozoans
                - (4) Suctorians
            - c. Distribution
            - d. Protists and Disease

IV. Modern Concept of the Cell

- A. Shapes and Sizes
- B. Structure and Function of Cell Parts
    - 1. Cytoplasm

2. Cell Boundaries
    a. Cell Wall
    b. Plasma Membrane
        (1) Diffusion
        (2) Osmosis
        (3) Active Transport
        (4) Others
3. Endoplasmic Reticulum
4. Nucleus (Control Center) DNA and RNA
5. Nucleolus
6. Mitochondria
7. Ribosomes (Microsomes)
8. Plastids
9. Golgi Complex (Lipochondria)
10. Centrosome

C. Cellular Physiology
    1. Necessary Nutrients
        a. Proteins and Enzymes
        b. Carbohydrates
        c. Lipids
        d. Minerals
        e. Vitamin and Growth Factors

2. Gas Exchanges

3. Respiration (Production of Internal Energy... ATP-ADP Cycle)

4. Utilization of Energy

    a. Muscle Contraction

    b. Nerve Transmission

    c. Synthesis of Macromolecules

    d. Bioluminescence

    e. Others

5. Photosynthesis and other forms of Biosynthesis

    a. Photolysis

    b. CO_2 Fixation

    c. Phosphorylation

    d. Protein Synthesis (D N A - R N A)

    e. Other Forms of Biosynthesis

        (1) Purple Bacteria

        (2) Sulfur Bacteria

        (3) Others

UNIT ONE: FOUNDATIONS OF LIFE

TEXTBOOK REFERENCE SUMMARY

Smith, Ella Thea

Exploring Biology 4th Edition

Overview	pp. 42-44
Chemical Background	pp. 20-35
Origin of Life	pp. 37-47
Modern Concept of the Cell	pp. 5-17 and 133-140

Exploring Biology 5th Edition

Overview	pp. 15-18 and 50-53
Chemical Background	pp. 53-63
Origin of Life	pp. 74-87, 107-121, and 428-461
Modern Concept of the Cell	63-70 and 270-278

Moon, Otto and Towle

Modern Biology 1960 Edition

Overview	pp. 1-10 and 12-13
Chemical Background	pp. 41-53
Origin of Life	pp. 12-20
Modern Concept of the Cell	pp. 21-30

Modern Biology 1963 Edition

Overview	pp. 12-20
Chemical Background	pp. 41-45 and 46-52
Origin of Life	pp. 91-125, 229-239, and 558-579
Modern Concept of the Cell	pp. 48-52 and 186-198

UNIT ONE: FOUNDATIONS OF LIFE

MASTER MATERIALS LIST

EQUIPMENT

- Centrifuge
- Hoffman apparatus
- Hot plate
- Illuminators
- Microscopes
- Periodic Chart of Elements
- Spectrometer
- Standard Spectrum Scale
- Waring Blendor

SUPPLIES - Non-consumable

- Bell jars
- Flannel boards
- Knife
- Magnets
- Mortar and pestle
- Prism
- Ringstands
- Scalpels
- Scissors
- Test tube racks
- Vacuum bottles
- Water trough, pneumatic

SUPPLIES - Consumable

- Glassware
  - Beakers
  - Bottles, plain widemouthed
  - Burette tube
  - Flasks, Erlenmeyer and Florence
  - Finger bowls (stacking bowls)
  - Glass panes
  - Glass slides and cover slips
  - Glass squares
  - Glass tubing
  - Graduated cylinders
  - Graduated pipettes
  - Mason jars
  - Milk bottles, ½ pint (or baby food jars)
  - Pipettes (eye dropper type)
  - Petri dishes
  - Test tubes
  - Thistle tubes
  - Watch glasses
  - Wide-mouthed mayonnaise jars

SUPPLIES - Consumable

- Chemicals
  - Acetone
  - Alcohol, Isopropyl
  - Ammonium chloride
  - Ammonium hydroxide
  - Ammonium sulfide
  - Benedict's solution
  - Biuret's reagent
  - Bromthymol blue powder
  - Chloroform
  - Clinitest tablets
  - Clove oil
  - Congo-red stain
  - Crystals of nickel, sulfate, copper sulfate, chrome alum, cobalt chloride and ferric chloride
  - Dibasic potassium phosphate
  - Dichlorophenolindophenol
  - Dilute acetic acid
  - Dilute nitric acid
  - Dilute sulphuric acid
  - Distilled water (from demineralizer)
  - Dry ice (Science Center)
  - Ether
  - FAA solution
  - Formaldehyde
  - Glucose (Dextrose)
  - Glucose-1-phosphate
  - Gum arabic
  - Hydrochloric acid
  - Hydrogen peroxide
  - India ink or carmine powder
  - Iron filings
  - Iodine-potassium iodide
  - Magnesium chloride
  - Magnesium ribbon
  - Manganese dioxide
  - Methylene blue stain
  - Mercury
  - Petroleum ether
  - pH paper (indicator paper)
  - Potassium dichromate crystals
  - Potassium permanganate crystals
  - Potassium phosphate
  - Powdered gelatin (or granulated)
  - Sodium bicarbonate
  - Sodium chloride
  - Sodium flouride
  - Sulfur
  - Tes-tape
  - Water-glass (concentrated solution of sodium silicate)

SUPPLIES - Consumable

Other materials
- Agar, nutrient and Saboraud's glucose
- Aluminum foil
- Artificial plants
- Blotting paper
- Bunsen burners
- Burette clamps
- Candles
- Cardboard or tagboard
- Cellophane (various colors)
- Cheese cloth
- Cigarettes
- Construction paper (various colors)
- Copper tubing and sheet copper
- Corks
- Corn starch
- Dropping bottles (plastic)
- Dry cell batteries (1.5)
- Filter paper
- Flocking paper backing
- Forceps
- Funnels
- Glue or rubber cement
- Inoculating needles
- Karo syrup
- Lens paper
- Long-handled spoon
- Millimeter rulers (transparent)
- Meter sticks
- One-hole and two-hole rubber stoppers
- Paper clips
- Paper towels
- Paraffin or sealing wax
- Ping pong balls
- Pinchcock clamps
- Plastic cottage cheese containers
- Platinum wire or nichrome wire
- Preserved animals (variety)
- Razor blades
- Rocks
- Rubber tubing
- Sandwich bags
- Scotch tape
- Silk cloth
- Squares of plexiglas or lucite
- String

SUPPLIES - Consumable

Other materials
- Teasing needles (dissecting needles)
- Thermometers
- Tooth picks and pipe cleaners
- Vaseline
- Whatman paper #1
- Wire mesh
- Wood box
- Wood splints (or probes)

LIVING AND FRESH MATERIALS

- Bean and corn seeds
- Bread, meat, milk, bananna, apple, grape and butter
- Cottage cheese, squash, grains of peppercorn, lettuce leaves, hay
- Culture of protozoa, yeast, and green algae
- Elodea sprigs
- Flowers of "jewel weed" and or "touch-me-not"
- Geranium and Iris leaves
- Geranium and Coleus potted plants
- Living animals and insects (frog, fish, fruit, flies, mouse and others)
- Oatmeal
- Pond water with decaying material
- Raw potato, carrot, onions, and egg
- Rhubarb, celery, and asparagus stems
- Rhoeo discolor (succulent plant)
- Rotting fruit such as tomato, apple, orange, lemon
- Slime mold
- Soda crackers
- Spinach leaves
- Tobacco plants, potted
- Tomato plants, potted
- Variety of living insects

UNIT ONE: FOUNDATIONS OF LIFE

ESTIMATED TEACHING TIME: 6 WEEKS

Suggested allotment of time in block below:

Mon.	Tues.	Wed.	Thurs.	Fri.	Week
Orientation	Orientation	Atoms	Atoms	Atoms Molecules	1st
Molecules Bonding	Bonding Structural Formulas	Bonding Structural Formulas	Optional	Origin of Life	2nd
Origin of Life	Microscope	Microscope	Microscope	Virus Rickettsia	3rd
Bacteria	Bacteria	Bacteria	Slime Molds Blue-green Algae	Optional	4th
Protozoa	Protozoa	Protozoa	Cell	Cell	5th
Cell	Cell	Cell	Cell	Optional	6th

UNIT ONE: FOUNDATIONS OF LIFE

CONCEPTS TO CONSIDER

Matter is anything that occupies space and has mass and inertia
Matter appears in any one of three forms: as a solid, as a liquid, or as a gas
All matter possesses energy in one form or another
Matter and energy can neither be created nor destroyed but can be transformed one into the other
Energy is the ability to do work. It may be potential or kinetic energy
Whenever energy is given off, or absorbed, a change in mass will occur ($E = mc^2$)
All living things have, to a greater or lesser extent, the properties of specific size and shape, metabolism, movement, irritability, growth, reproduction, and adaptation

TEACHING APPROACH (Methods and Activities)

Discuss the difference between living and non-living things

- Prepare a display of items that are living and non-living
- Students take a short test on the displayed items and decide as to whether the items are living or non-living
- As a result of short test and class discussion, students make a list of activities that are characteristic of living things
- Guide discussion toward the concept that living and non-living things are similar in that they are composed of matter (molecules)

Review information about matter and energy (junior high school science)

- Prepare a PRE-TEST about basic concepts concerning matter and energy
- Give PRE-TEST to students to determine the retention of material learned in junior high school concerning matter and energy
- Based on results of PRE-TEST review:

    All matter has the characteristic of impenetrability
    All matter occupies space, has mass and inertia
    Matter and energy cannot be destroyed nor created
    Matter is composed of small particles
    etc.

UNIT ONE: FOUNDATIONS OF LIFE

DEPTH PROBE

- LIVING VS. NON-LIVING, pp. 5-6 (Average Student Basic Activity): Sometimes non-living things have qualities of living things. Students work in groups.

- MERCURY "AMEBA," p. 7 (Average Student Basic Activity): Demonstrates non-living things may simulate characteristics associated with living things. Students work in groups or teacher demonstrations.

- "CHEMICAL GARDENS," p. 8 (More able Student Optional Activity): Sometimes non-living things exhibit qualities of living things. Students work in groups or teacher demonstrations.

"TOOLS" FOR EXTENDING CONCEPTS

- Plan a bulletin board display to visualize characteristics of living things vs. non-living things.
- Prepare a bulletin board entitled "FACT OF THE MATTER IS" which will show the general properties of matter, states of matter, and similar information.
- Show filmstrip "Matter and Energy" (Color) S-35.
- Show film "Matter and Energy" Fsd 531-1.

PLANNING AHEAD

- Prepare enough "kits" for the entire class to use in learning about the parts of an atom. See pages 16-17.
- Locate and collect several spectroscopes to be used later in the week.
- Make arrangements to use the PERIODIC CHART OF ELEMENTS for at least one week. Prepare a ditto sheet for each student showing the PERIODIC CHART OF ELEMENTS.
- Make arrangements to use the STANDARD SPECTRUM SCALE chart.
- Assign students the task of bringing in samples of as many elements as they can find for a classroom display.
- Prepare a display of several common elements.
- Give a student group the job of a bulletin board display about ATOMS.
- Prepare a ditto sheet showing a blank continuous spectrum to help students during an activity using the spectrograph. See pages 22-23.
- Order small tobacco plants (potted) for a laboratory experiment scheduled for three weeks from now.

UNIT ONE: FOUNDATIONS OF LIFE

BROADENING "CONTENT HORIZONS"

Teacher References:

- Holton and Roller. Foundations of Modern Physical Science. Reading, Mass.: Addison-Wesley, 1958. (Title III - Collection)
- Joseph, Brandwein, Morholt, Pollack, and Castka. Teaching High School Science: A Sourcebook for the Physical Sciences. New York: Harcourt, Brace and World, 1961.
- Bonner and Phillips. Principles of Physical Science. Reading, Mass.: Addison-Wesley, 1957.
- Wald, George. "Innovation in Biology," Scientific American, (Sept., 1958)

Student References:

- Schrodinger, Erwin. "What is Matter," Scientific American, (Sept., 1953)
- Solomon, A. K. Why Smash Atoms.

Textbook References:

- Smith, Ella Thea. Exploring Biology, 5th Edition. pp. 15-18 50-53
- Moon, Otto, and Towle. Modern Biology. pp. 12-20

LIVING VS. NON-LIVING

PURPOSE

Sometimes non-living things have qualities of living things. This experiment will help the student to understand some of these differences.

ACTIVITY MATERIALS

Living animal (such as a fish, frog, or mouse)
Bean or corn seeds
Large Copper Sulphate crystal (any crystal)
Burning candle
Etherized fly (or any insect)
Artificial plant
Dead fly
Rocks
Paper clips
Preserved insect

WHAT TO DO

Place above objects and items into three exhibits and have students identify items as to whether living or non-living.

Exhibit 1

a. Living animal
b. Paper clip
c. Artificial plant
d. Medium size rock
e. Burning candle
f. Potted plant

Exhibit 2

a. Living insect (in glass jar)
b. Etherized insect on a glass slide
c. Preserved insect in a petri dish

Exhibit 3

a. Corn or bean seeds that have been soaked and torn apart
b. Unsoaked seeds
c. Seeds that have been soaked in alcohol and then dried

OVERVIEW
LIVING VS. NON-LIVING
MATTER AND ENERGY

UNIT ONE: FOUNDATIONS OF LIFE

DISCUSSION

For Teacher Reference:

Draw student's attention to concepts that living things have: Organization of matter (molecular - large proteins such as protoplasm, cellular, organism); Metabolism (intake of energy-rich materials, storage, conversion, and release of energy); Growth and development to characteristic size and shape for each kind; Reproduction (biological continuity, heredity)

One difficulty in trying to define life or the living state is that no one criterion is adequate to define it. Therefore, we have to use a combination of criteria to characterize the nature of living things. Actually there are gradations between non-living and living things. The viruses are an example. In crystalline form a virus shows a complex molecular organization but shows none of the other criteria. When introduced into the living cell of its host it manifests practically all of these criteria. The question is, "Is it living?" Some biologists say yes and others say no. This disagreement emphasizes the difficulty of setting up criteria for distinguishing between living and non-living things.

Adapted from Lawson, and Paulson. Laboratory and Field Studies in Biology: A Sourcebook for Secondary Schools. New York: Holt, Rinehart, and Winston, 1960. p. 51.

MERCURY "AMEBA"

PURPOSE

To show that non-living things may simulate characteristics associated with living things

ACTIVITY MATERIALS

Mercury
Potassium dichromate crystals
Dilute nitric acid
Flat-bottomed glass bowl
Wooden probe
Water

WHAT TO DO

Fill a flat-bottomed glass bowl half full of water. Add a drop of mercury about the size of a pea to the bowl. Add 10 to 15 ml. of dilute nitric acid to this solution. Place a crystal of potassium dichromate in the solution and move it slowly toward the mercury by using a wooden probe. Be sure never to allow the crystal to touch the mercury.

DISCUSSION

For Teacher Reference:

Ask students:

What observations do you make when the crystal is close to the mercury?
What type of movement best describes the action of the mercury?
How does this activity differ from actual movement of living things?

For Reference:

"The physico-chemical basis of this behavior: mercury has an exceedingly high surface tension, the highest of any known liquid, and for this reason assumes an approximately spherical form on a surface, though flattened by its own weight. The potassium dichromate in nitric acid oxidizes the surface of the mercury, lessening momentarily the surface tension at this point, causing local outflow of mercury. Such points of oxidation, distributed, asymmetrically over the surface from moment to moment, lead to the motions and cleavages you have observed."*

---

*Wald, George, et al. "26 Afternoons of Biology." Reading, Mass.: Addison-Wesley, 1962. p. 10. (Reprinted with permission of publisher.)

"CHEMICAL GARDENS"

PURPOSE

Sometimes non-living things exhibit qualities of living things. This demonstration is done to stimulate thinking about inorganic growth and true growth.

ACTIVITY MATERIALS

Wide-mouthed mayonnaise jar (or very large beaker)
Concentrated solution of sodium or potassium silicate
(commonly known as water-glass)
Clean sand
Crystals of: nickel sulfate, copper sulfate, chrome alum, cobalt chloride or ferric chloride

WHAT TO DO

Stir 10 cc commercial water-glass into a wide-mouthed mayonnaise jar (quart jar) containing a 100 cc of water. Cover the bottom of the jar with clean sand. Drop into solution one crystal (size of a match head) of several different salts, such as nickel sulfate, copper sulfate, chrome alum, cobalt chloride, etc. Some results will appear in 30 minutes. Crystals should "grow" to the top of the jar in 24 hours. To make the "garden" permanent, siphon out the water-glass carefully and fill immediately with water. Cover tightly.

DISCUSSION

Ask the Student:

How soon after crystals were placed in solution did growth appear?
How long did it take for the maximum growth to occur?
How do you account for the growth of the crystal? Why did the growth stop?
Can you compare growth in crystal (inorganic growth) with true growth (in a living cell)?

For Teacher Reference:

The surface of the salt crystal begins to dissolve and reacts with the silicate to form an insoluble silicate. Water passes through the insoluble membrane of the silicate, causing the drop of liquid around the crystal to become large. Finally the membrane of insoluble silicate is broken, and a drop of soluble salt is shot out. The solution again reacts with water-glass at the surface of the drop; the action is repeated, and the "chemical garden" grows.

UNIT ONE: FOUNDATIONS OF LIFE

CONCEPTS TO CONSIDER

There are three principle particles which make up atoms: positive protons, neutral neutrons, and negative electrons
Protons and neutrons are found in the center or nucleus of the atom
All atoms of one kind are of the same or nearly the same weight
Most atoms are able to combine with each other either in pairs or in more complicated structures
One or more electrons revolve (or form cloud-like or wave-like areas) in regions called shells (energy levels) designated by letters K, L, M, N, O, P, Q
The number of electrons in any atom equals the number of its protons
An orbital is a path of an electron around the nucleus of the atom
No more than two electrons can occupy the same orbital (Pauli exclusion principle)
Isotopes are atoms of the same element having a different number of neutrons and a difference in atomic weight
An element is a substance which is made up of the same kind of atoms

TEACHING APPROACH (Methods and Activities)

Discuss the meaning of an element

- Students and teacher prepare a display of the various common elements by placing a small quantity of each element in a petri dish or syracuse dish. Label each dish plainly and carefully
- Teacher displays the PERIODIC CHART OF CHEMICAL ELEMENTS in the front of the room and tries to correlate the common element display with chart
- Prepare a ditto copy of the PERIODIC CHART OF CHEMICAL ELEMENTS for each student for future reference
- Students discuss the concept that an element is a substance which is made up of small particles of the same kind called atoms
- Demonstrate the characteristics of some different elements. See pages 18-19.

Discuss and learn the parts of an atom

- Teacher prepares a simple flannel board demonstration on the parts of an atom. See pages 13-14.
- Students learn the parts of an atom by use of special "kits." Students work in pairs for this activity. See pp.16-17for suggestions on preparation of the "kits."
- Students prepare models (in three-dimensions) of atoms, starting with simple forms and finally progressing to the more complex atoms
- Students may want to prepare mobiles of atoms to hang from the ceiling of the classroom. Around Christmas time, models of atoms can be hung on a tree instead of other decorations

UNIT ONE: FOUNDATIONS OF LIFE

- Ask students to learn about "fingerprint" method of element identification by using the grating spectrograph. Students will work in teams to accomplish this activity. See pages 22-23 for more information.
- Students can prepare a chart showing the name of the subatomic particles, their symbol, charge, mass, and other information. See page 15.
- Demonstrate the method locating subatomic particles by use of "cloud chamber." See page 20 for instructions on demonstration (pages 20 and 21).

DEPTH PROBE

- ATOM STRUCTURE pp. 13-14 (Average Student Basic Activity) To demonstrate the atom and its parts. Teacher demonstration.

- SUBATOMIC PARTICLES, p. 15 (Average Student Basic Activity--Optional) Subatomic particles, their symbol, charge and mass. Student homework assignment.

- ATOM "KITS" pp. 16-17 (Average Student Basic Activity) Individual flannel board demonstrations of the atom and its parts. Students work individually or in pairs.

- CHARACTERISTICS OF AN ELEMENT, pp. 18-19 (Average Student Basic Activity) Preparation of oxygen gas to demonstrate characteristics of an element. Teacher demonstration.

- SUBATOMIC PARTICLES AND THE "CLOUD CHAMBER" pp. 20-21 (More able Student Optional Activity) Using the "cloud chamber" to demonstrate subatomic particles. Teacher demonstration or students work in groups.

- "FINGERPRINTING" ELEMENTS, pp. 22-23 (More able Student Optional Activity) Distinguishing elements by the "fingerprint" method. Students work in groups.

"TOOLS" FOR EXTENDING CONCEPTS

- Plan a bulletin board display showing the various parts of an atom (this may be a student group activity).
- Assign some students to give reports on John Dalton, Dmitri Mendeleyev, Henry Moseley, Neils Bohr, and others.
- Plan to show filmstrip "The Atom," set 1 (Life-1955, Color) S-97.
- Plan to show film "A is for Atom" (16 minutes, Color) Fsd 541.2-13.
- Assign students the preparation of a three-dimensional model of an atom of their choice.
- Assign some student a report on the subject of ANTI-MATTER and the research being done in this field.

PLANNING AHEAD

- Set up the electrolysis equipment and check power source to see if it is in good working order. See page 39
- Collect chemicals for demonstrations and experiments coming up (sulfur, iron filings, sulfuric acid, limewater, brom thymol blue, magnesium ribbon, etc.)
- Locate magnets
- Make plans to interest some student in the building of Chaos machine. See pages 27-28
- Assign students the task of bringing in various colored "pop-it" beads to supplement class needs
- Locate molecular model building set (professional set) for use in class
- Prepare a hay infusion for viewing in 2 weeks. See pages 77-79.
- Order Sclerotia of slime molds from Science Center

BROADENING "CONTENT HORIZONS"

Teacher References:

- Keenan, and Wood. General College Chemistry, 2nd Edition. New York: Harper Bros., 1961.

- Selwood, P. W. General Chemistry, 3rd Edition. New York: Henry Holt and Co., 1959.

- Sienko, and Plane. Chemistry, 2nd Edition. New York: McGraw-Hill, 1961. (Title III - Collection)

- Boylan, Brownlee, Fuller, Hancock, Sohon, and Whitsit. Elements of Chemistry. Boston: Allyn and Bacon, 1962.

- Asimov, Isaac. Inside the Atom. Abelar-Schuman, 1956

- Bischof, G. Atoms at Work. New York: Harcourt, Brace and World, 1951.

- Jones, G. O., J. Rotblat, and G. J. Whitrow. Atoms and the Universe. New York: C. Scribner and Sons, 1956. (Title III - Collection)

UNIT ONE: FOUNDATIONS OF LIFE

Student References:

- Articles from Scientific American

Bethe, Hans A. "What Holds the Nucleus Together," (Sept., 1953)

De Benedetti, Sergio. "Mesonic Atoms," (Oct., 1956)

Gell-Mann, Murray, and E. P. Rosenbaum. "Elementary Particles," (July, 1957)

Hofstadter, Robert. "The Atomic Nucleus," (July, 1956)

Marshak, Robert. "Pions," (Jan., 1957)

Mayer, Maria G. "Structure of the Nucleus," (March, 1951)

Morrison, Philip. "The Neutrino," (Jan., 1956)

Morrison, Philip and Emily. "The Neutron," (Oct., 1951)

Peierls, R. E. "Models of the Nucleus," (Jan., 1959)

Sergio, Emilio, and Clyde Weigand. "The Anti Proton," (June, 1956)

Weisskopf, Victor, and E. P. Rosenbaum. "A Model of the Nucleus," (Dec., 1955)

Marshak, Robert. "The Nucleer Force," (March, 1960)

Penman, Sheldon. "The Moon," (July, 1961)

Textbook References:

- Moon, Otto, and Towle. Modern Biology. pp. 41-45
- Smith, Ella Thea. Exploring Biology, 5th Edition. pp. 53-58

ATOM STRUCTURE

PURPOSE

Teaching the parts of an atom by use of the flannel board

ACTIVITY MATERIALS

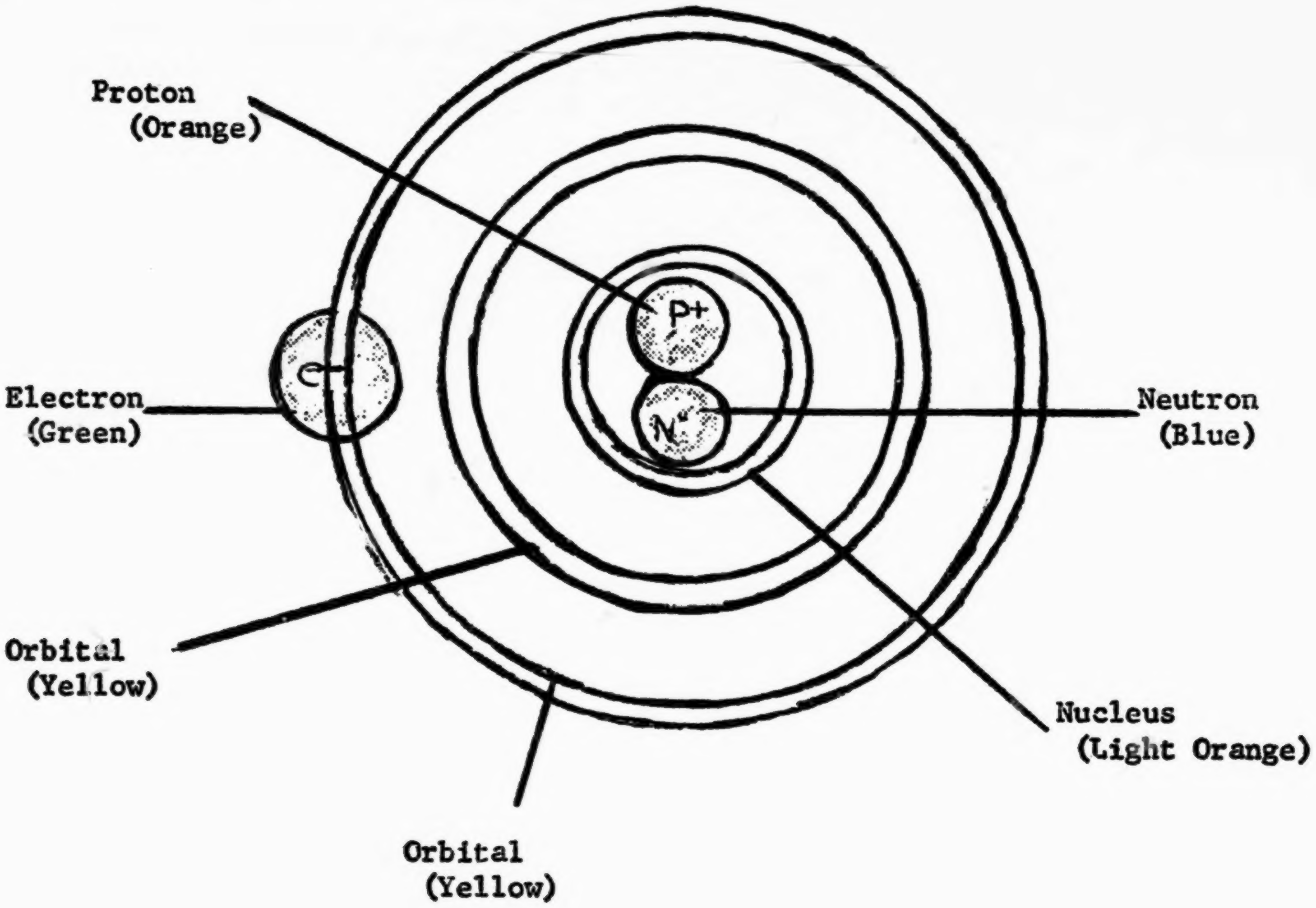
Flannel board
Cutouts of parts of the atom (use construction paper of various colors)
Flocking paper backing for cutouts

WHAT TO DO

Cut out of construction paper of various colors the following items: Several circles to represent orbitals of electrons (yellow). Many small circles to represent electrons (green). Many small circles to represent protons (orange). Many small circles to represent neutrons (blue). One small circle to represent the nucleus (light orange).

Place all cutouts on flannel board but not in sequence. Call students to flannel board one at a time to help put the atom together. Explain and discuss the theory behind energy levels and how an electron is able to give off energy when moved out of its intended orbital. Build a simple hydrogen atom, then a helium atom. With the use of reference materials allow students to build more complicated atoms on the flannel board.

	ELECTRON NUMBER	PROTON NUMBER	NEUTRON NUMBER
Hydrogen	1	1	0
Helium	2	2	2
Lithium	3	3	4
Berylium	4	4	5
Boron	5	5	6
Carbon	6	6	6
Nitrogen	7	7	7
Oxygen	8	8	8
Fluorine	9	9	10
Neon	10	10	10


Proton (Orange)
P+
e−
Electron (Green)
N°
Neutron (Blue)
Orbital (Yellow)
Nucleus (Light Orange)
Orbital (Yellow)

UNIT ONE: FOUNDATIONS OF LIFE

SUBATOMIC PARTICLES

PURPOSE

To supply a means for student enrichment in the field of subatomic particles. . . . Reference material for class work or homework assignment.

Name	Symbol	Charge	Mass	How Formed
Gamma Ray (Photon)	γ	0	0	
Neutrino	ν	0	0	
Electron	e^-	-	1	
Positron	e^+	+	1	
Mu Meson	μ	+ or -	206	
Pi Meson	π	+ or -	273	
Pi Meson	π	0	264	
Tau Meson	τ	+ or -	967	
Kappa Meson	K	+ or -	967	
Theta Meson	θ	0	967	
Proton	p^+	+	1836	
Anti Proton	p^-	-	1836	
Neutron	n	0	1839	
Lambda Particle	Λ	0	2182	
Sigma Particle	Σ	+ or -	2328	
Xi Particle	Ξ	-	2585	

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*Trinklein, and Huffer. Modern Space Science. New York: Holt, Rinehart and Winston, 1961. p. 22. "Reprinted by special permission of the publisher from MODERN SPACE SCIENCE, by Trinklein and Huffer, 1961, by Holt, Rinehart and Winston, Inc."

ATOM "KITS"

PURPOSE

To aid students in learning about the parts of an atom

ACTIVITY MATERIALS

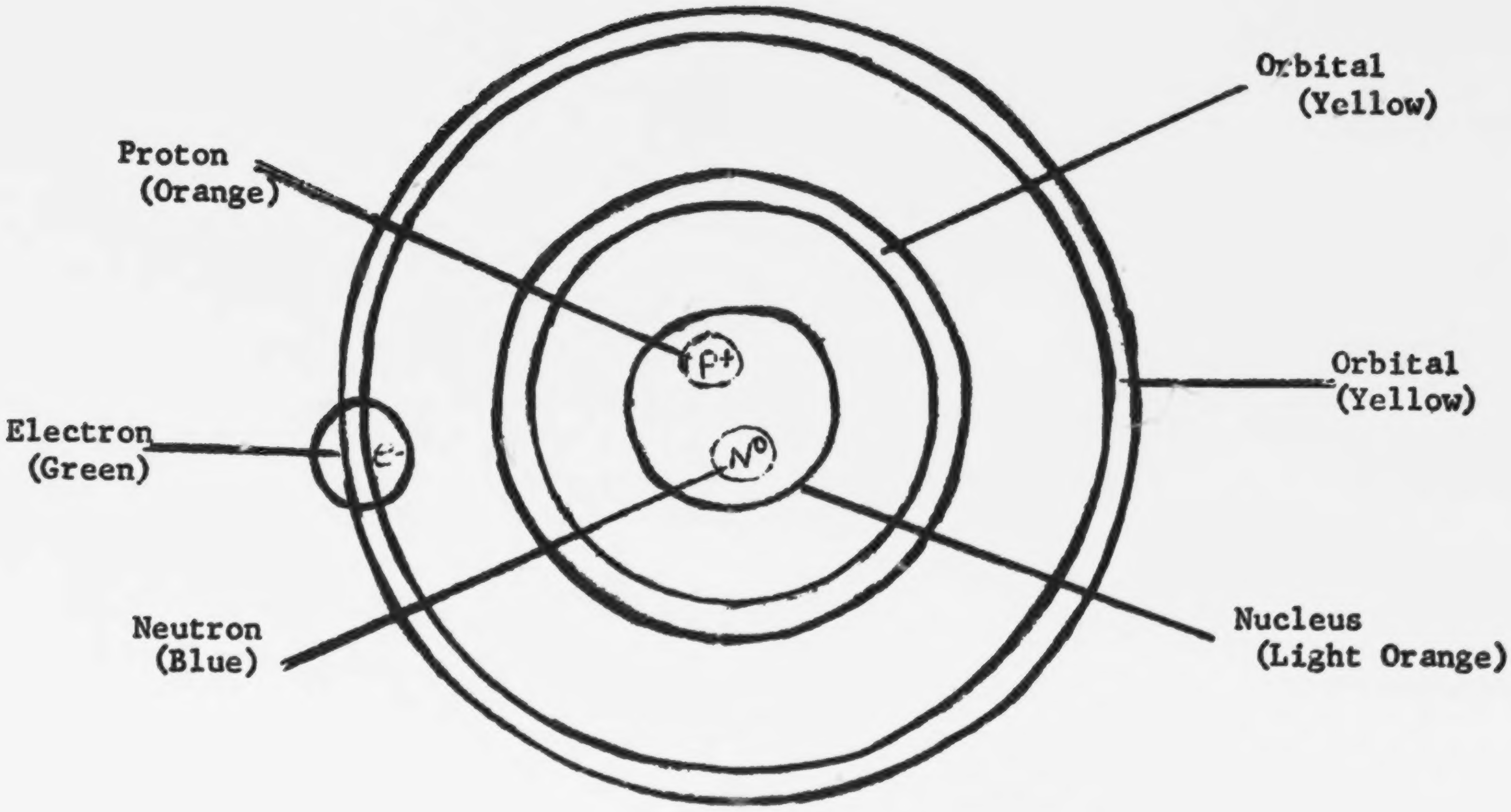
Sandwich bag, envelopes, or any large storage envelope
Various colors of construction paper
Scissors
Flocking backing for cutouts cut into small strips
Small individual flannel boards

WHAT TO DO

Students may prepare cutouts of an atom as an assignment for homework or teacher may prepare all kits in advance. Tagboard stencils of the various parts of the atom should be prepared so that all atom kits will be uniform in size and color. After parts of the atom have been cut out of construction paper: protons (in orange), electrons (in green), orbitals (in yellow), nucleus (in light orange), neutrons (in blue) place a small strip of flocking paper on each cutout.

Each envelope should contain a written inventory: 5 yellow orbitals cut so that each one is slightly larger than the next. . . label the smallest of the orbitals with a "K" (this is the orbital closest to the nucleus); 1 light orange nucleus; 25 green electrons; 25 blue neutrons; 25 orange protons.

Pass out individual flannel boards--one to every two students. Each student pair will have a kit of cutouts. Give directions to the class on the kind of atom to build for practice. Allow students to discuss the building with one another. Start with a comparatively easy atom and progress to a more difficult one. Students should use some reference material to help them build the correct atom.


Orbital
(Yellow)
Proton
(Orange)
P+
Orbital
(Yellow)
Electron
(Green)
e-
N0
Neutron
(Blue)
Nucleus
(Light Orange)

CHARACTERISTICS OF AN ELEMENT

PURPOSE

To demonstrate the characteristics of an element--oxygen gas

ACTIVITY MATERIALS

- Test tubes
- Rubber tubing
- Glass jars (several)
- Glass squares
- One-hole rubber stopper
- Dropping funnel
- Water trough
- Water
- Manganese dioxide
- Hydrogen peroxide
- Two-hole rubber stopper
- Pinchcock clamp
- Sodium peroxide
- Sulfur
- Long-handled spoon
- Magnesium ribbon
- Wood splints

WHAT TO DO

*A. Fill a trough about ¼ full of water. Fill several glass jars with water and invert into water trough. Place about 1 gram of manganese dioxide in a test tube and add 50 ml of 3% hydrogen peroxide solution. Place a one-hole rubber stopper with a delivery tube attached to test tube. Insert tubing into inverted glass jar to collect oxygen gas. Remove glass jar from the trough after all water has been driven out and place glass square over top of jar so that the gas will not be able to escape. (Figure 1)

*B. Place 10 grams of sodium peroxide in a dry Erlenmeyer flask. Fit a two-hole stopper with a dropping funnel and delivery tube. Water is added drop by drop, and the oxygen is collected over water as is described in A above. (Figure 2)

Place a glowing splint in a jar of oxygen gas. What happens to the glowing splint? Place a spoonful of glowing sulfur in a jar of oxygen gas. What happens? Ignite a piece of magnesium ribbon and place it into a jar of oxygen gas. What happens? Allow the wood splinter to burn as long as possible in the jar of oxygen gas. Why does the flame go out?

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*Richardson, Methods and Materials for Teaching General and Physical Science. New York: McGraw-Hill, 1951. pp. 435-436

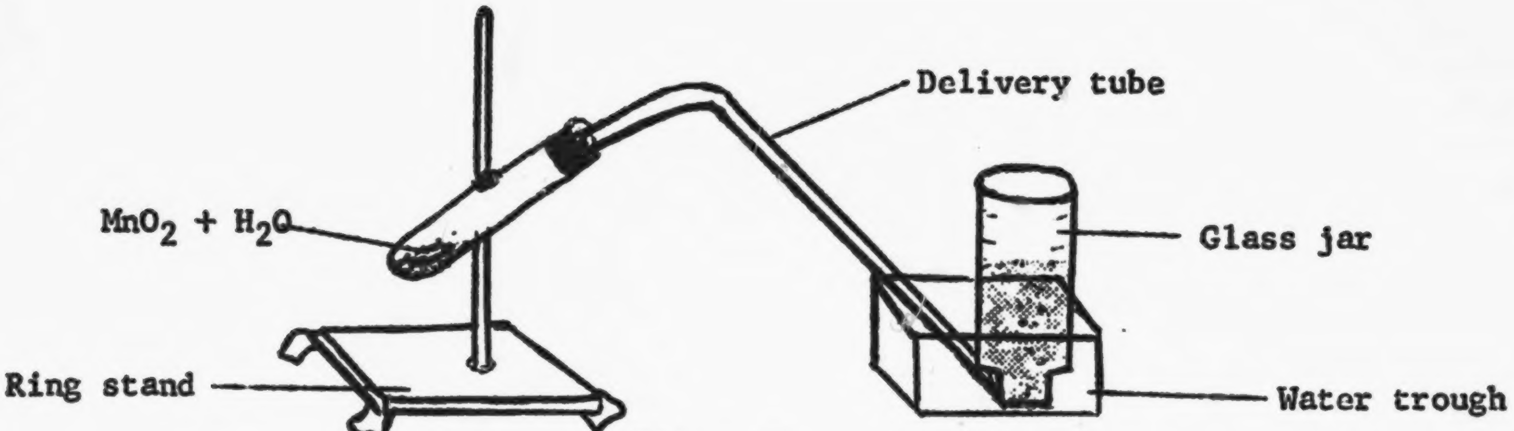
Delivery tube
$MnO_2 + H_2O$
Glass jar
Ring stand
Water trough

Figure 1

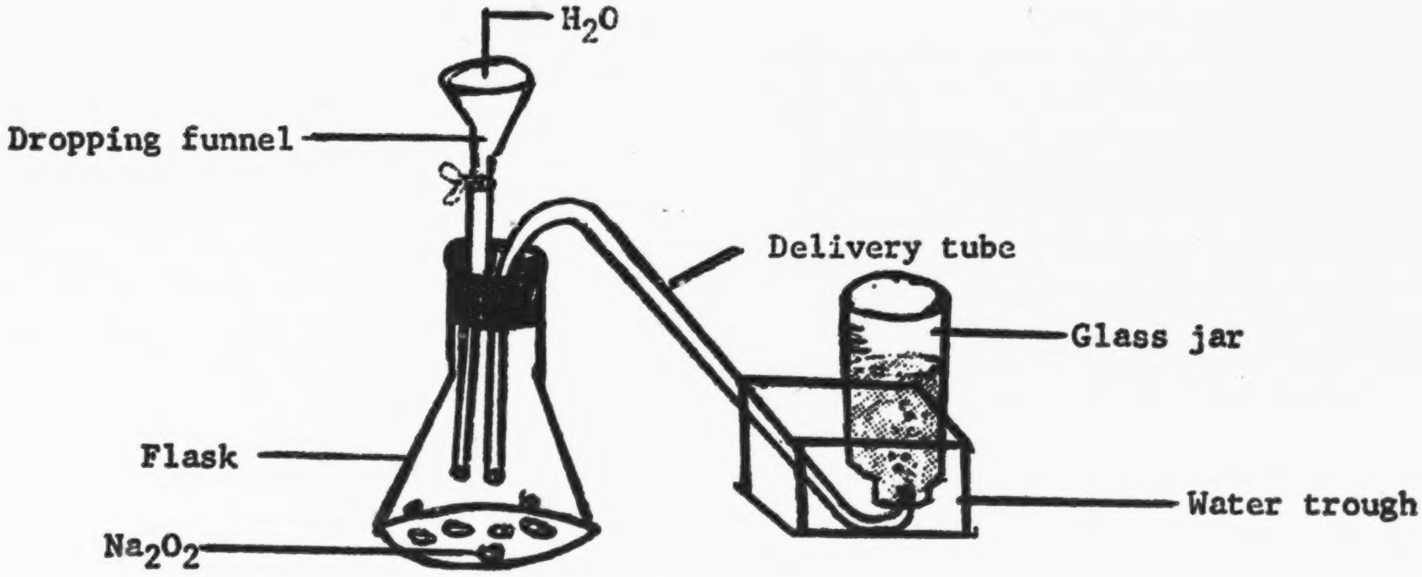
H_2O
Dropping funnel
Delivery tube
Glass jar
Flask
Na_2O_2
Water trough

Figure 2

SUBATOMIC PARTICLES AND THE "CLOUD CHAMBER"

PURPOSE

To demonstrate visible evidence of cosmic rays or other charged particles by condensation trails formed as these particles pass through.

ACTIVITY MATERIALS

Small, wide-mouthed vacuum bottle and its stopper
An ordinary cottage cheese container of thin plastic
Small pieces of plastic ¼" high (spacers)
5" length of copper tube about ½" to 3/4" in diameter
Disk of sheet copper 2-3/4"
Flat black paint
½" band of thin blotting paper
4" square of plexiglas or lucite 1/16" to 1/8" thick
Dry ice
Denatured Ethyl alcohol
Silk cloth

WHAT TO DO

*Take a 5" length of copper tube, ½" to 3/4" in diameter, heat it and then use it to melt a hole through the center of the bottom of the plastic container (cottage cheese container). The fit should be slightly loose, (if cracks occur in the plastic, they will not affect the operation). A hole of the same size is then drilled or melted through the center of the vacuum-bottle stopper. This fit should also be loose to permit the escape of carbon dioxide from the vacuum bottle. To ensure such venting, use a small nail to punch a hole through the thermos stopper halfway between the center hole and the edge of the stopper.

Next, solder the 2-3/4" disk of copper sheet against one end of the copper tube as in Figure 1. Paint the top surface of the copper disk with flat black paint for visual contrast. Assemble parts as shown in Figure 1. At the top of the plastic container against the inside walls, place a ½" band of blotting paper, its ends stapled together to form a ring. It should fit snugly on a slight bias. The container cover is simply a 4" plexiglas or lucite, 1/16" to 1/8" thick.

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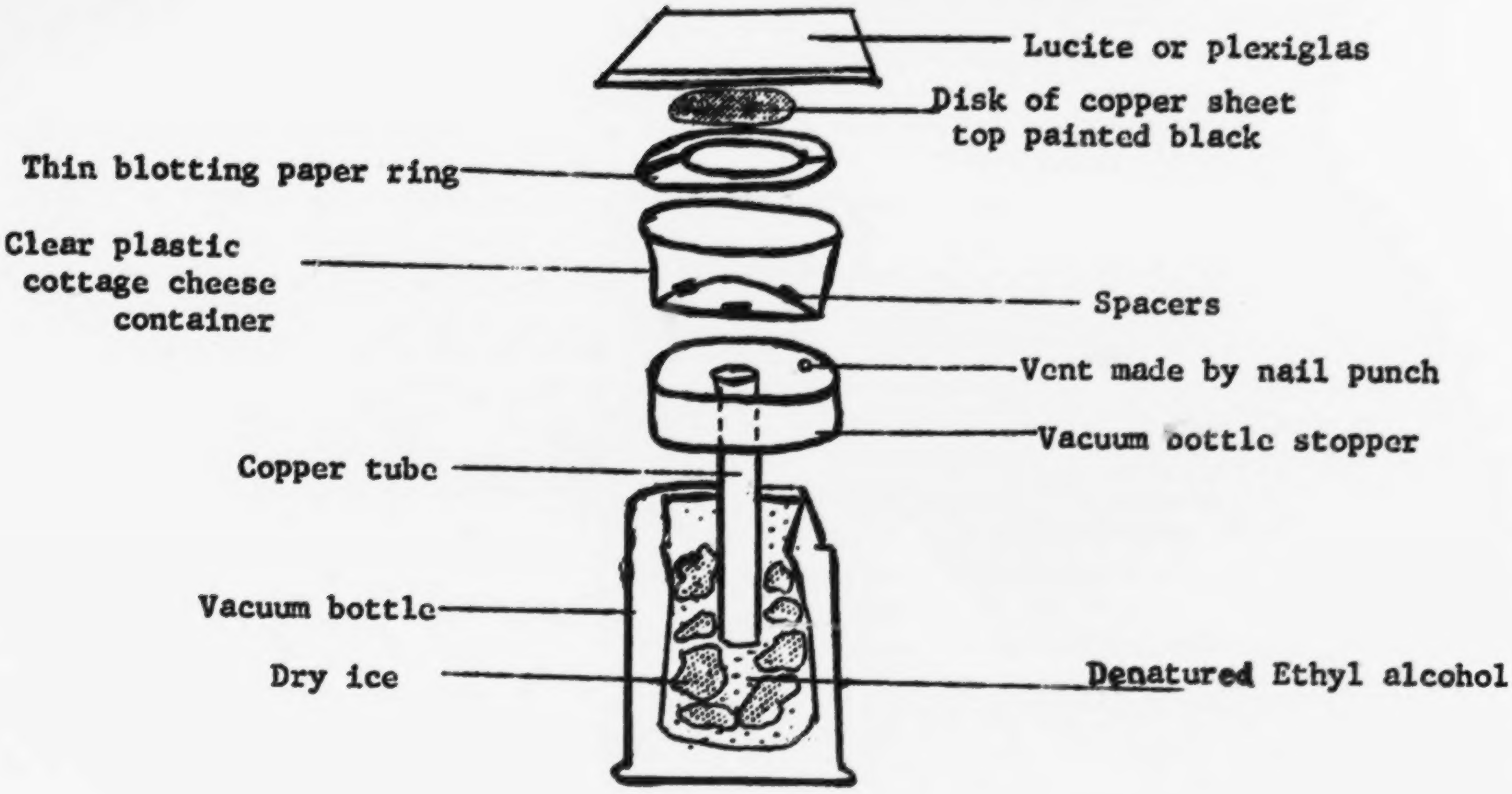
*Adapted from Joseph, Brandwein, Morholt, Pollack, and Castka. Teaching High School Science: A Sourcebook for the Physical Sciences. New York: Harcourt, Brace, and World, 1961. p. 564 . (Reprinted by permission of the publisher.)

Be sure to use gloves or tongs for the hands for the next operation. Load the vacuum bottle with small pieces of dry ice, and fill with denatured Ethyl alcohol. The dry ice will boil at first and then stop. Ventilate the room to carry away alcohol fumes. After a short time, the dry ice will soften in the alcohol. Lower the free end of the copper tube assembly into the vacuum bottle, and secure the stopper tightly. Wet the ring of blotting paper with denatured Ethyl alcohol. Place lucite cover on the plastic container, and rub the cover with a silk cloth to give it an electrostatic charge.

Next shine the beam of a small projector or small pocket flashlight with a condensing lens through the chamber, and look down into the chamber. Cosmic rays tracks will soon be seen traversing the chamber.

ASSEMBLY FOR DIFFUSION CLOUD CHAMBER


Lucite or plexiglas
Disk of copper sheet top painted black
Thin blotting paper ring
Clear plastic cottage cheese container
Spacers
Vent made by nail punch
Vacuum bottle stopper
Copper tube
Vacuum bottle
Dry ice
Denatured Ethyl alcohol

"FINGERPRINTING" ELEMENTS

PURPOSE

To understand and learn about the concept of identifying elements through the use of the grating spectroscope

ACTIVITY MATERIALS

Spectroscope
Heavy gauge wire with a platinum or nichrome tip
Chemical salts
Bunsen burner
Standard Spectrum Scale
Ditto sheets of blank continuous spectrum lines
Living tissues, such as green leaves, wet onion tissue, ground bone, meat, and others

WHAT TO DO

Teacher should examine the spectroscope to be sure that it is calibrated to read 5900 angstrom units or Na (sodium) on the linear scale.

Student may use several methods to accomplish this activity.

> Use a heavy gauge wire holder with a nichrome or platinum tip shaped into a small loop. The loop part of the holder should be dipped into HCl and flamed over the bunsen burner. This is done to burn off any substances that may have accidentally stuck to the loop end of the wire. Follow this procedure after each viewing of a new chemical salt.
>
> Moisten the end of the loop and dip it into a container holding the chemical salt. Hold the loop over a clean flame. Start spectroscopic examination with a flare of NaCl. You will see a bright yellow flame. Observe this flame (flare) through the spectroscope. You should see a bright yellow line where yellow would be in the solar spectrum. This is characteristic of a sodium flame. Check the STANDARD SPECTRUM SCALE chart at the front of the room. What are the number of angstrom units?
>
> Observe flares from a mercury vapor lamp, calcium salts, copper salts, and others through the spectroscope. Plot the emission spectrum of each on your ditto sheet with colored pencils. Be sure to note the angstrom units for each. Be sure that each new salt flare is not taken up with the wire loop until the loop has been dipped in HCl and flamed.

Observe the spectrum of white light. What kind of spectrum is produced? (Probably the blue end of the spectrum is missing; however, the reds and greens are bright.)

Observe the sun. (Do not look directly at the sun, but look just to either side of it. Notice that the violet and blue colors are bright.) What kind of spectrum does the sun produce?

Observe a fluorescent light. Are you able to identify neon in this light? (Neon has bright lines in the red, green, and yellow section of its spectrum.)

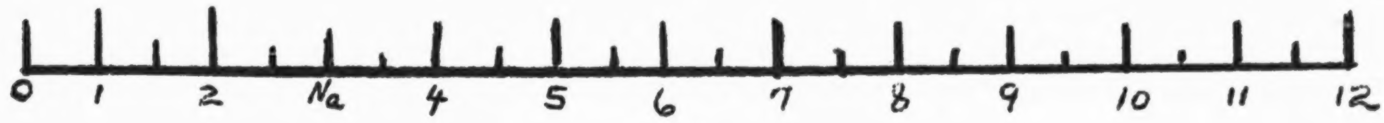
ALTERNATE METHOD

Dissolve in distilled water, salts such as chlorides and sulfides of Na, Ca, Fe, and others. Soak filter paper or clean paper towel sections in the salt solutions. Hold the soaked paper in a bunsen burner with tongs or support the soaked paper on a screen on a ringstand above the flame. Care should be taken not to contaminate the bunsen burner. Observe these flares through the spectroscope. Plot the emission spectrum of each flare with colored pencils.

Burn living materials, such as green leaves, wet onion tissue, filter paper soaked in meat juice, animal blood, ground bone, and others. Observe these flares through the spectroscope. Plot the emission spectrum of each with colored pencils.

Compare the spectra of living things with non-living salt solutions and try to correlate any similarities found. Are any of the inorganic salts found in the living materials tested? If so, which ones? How are we able to determine this?

EXAMPLES OF EMISSION SPECTRUM BLANKS



Exp#1 ________

4000
5000
6000
7000
7600

Exp. # 1 ________

CONCEPTS TO CONSIDER

Molecules are the smallest particles of a substance that can exist in the free state and which have all the properties of the substance.

Molecules of all substances are in constant motion. In gases the molecules move in straight lines colliding with one another and the walls of their container, causing gas pressure. In liquids, this molecular motion may be observed by brownian movement of dust particles on the surface of the liquid. In solids, the particles vibrate in a limited fashion due to strong attractive forces between the molecules (molecular-kinetic theory).

When two or more elements combine they always do so in a fixed or definite proportions by weight (principle of definite proportions).

If an element unites with another element in more than one proportion by weight, the weights of one element which unite with a fixed weight of the other bear a simple ratio to each other (principle of multiple proportions).

TEACHING APPROACH (Methods and Activities)

Discuss the difference between an element and a compound

- Exhibit a display of many common compounds around the classroom. Students will bring various compounds for the display
- Teacher gives flannel board demonstration to review the parts of an atom, guiding the class toward the building of a simple molecule
- Students and teacher build molecules from "pop-it" beads or other materials. Models should include simple molecules first and then more complicated molecules such as carbohydrate, amino acid, fat molecule
- Demonstrate the motion of molecules by using the Chaos machine. See pages 27-28
- Students observe brownian movement under low power of microscope. See page 31
- Use an alcohol swab on some student, swab the black board with the alcohol swab. Elicit from the class what has happened?

Discuss the differences between a physical and chemical change

- Many students may have seen demonstration cited on pages 29-30, but a quick review of events will be worthwhile
- Demonstrate electrolysis of water. See pages 39-39-a

Discuss briefly the shorthand used in writing chemical equations

UNIT ONE: FOUNDATIONS OF LIFE

DEPTH PROBE

- DIFFUSION BY MEANS OF CHAOS MACHINE, pp. 27-28 (Slow Student-Optional). Chaos machine to demonstrate that molecules are always in motion. Teacher demonstration.

- CHANGES - PHYSICAL AND CHEMICAL, pp. 29-30 (Average Student Basic Activity). Differences between a mixture and a compound. Students work in groups or teacher demonstration. (If not done in group)

- BROWNIAN MOVEMENT - "SMOKE BOX," p. 31 (Average Student Basic Activity). Demonstrating Brownian movement. Students work in pairs.

- DIFFUSION, p. 32 (Average Student Basic Activity). Diffusion of molecules. Teacher demonstration.

- DIFFUSION, p. 33 (More able Student Basic Activity). To demonstrate an important process operating in living and non-living systems--principle of diffusion. Students work in pairs.

- MOLECULE BUILDING, pp. 34-36 (Average Student Basic Activity). Building models of molecules. Students work in groups.
- MOLECULE BUILDING, p. 37 (Slow Student Basic Activity). To aid students in understanding the concept of molecule structure by a visual aid...flannel board. Teacher demonstration.

- "CARDBOARD" CRYSTALS, pp. 38-38-a (More able Student - Optional). Building crystal shapes out of cardboard. Students work in groups.

- SPLITTING CHEMICAL BONDS, pp. 39-39-a (More able Students - Optional). Electrolysis of water. Teacher demonstration.

"TOOLS" FOR EXTENDING CONCEPTS

- Students prepare a bulletin board entitled SYMBOLS AND ALCHEMY showing the difference in use of symbols today and in medieval times.
- Assign students an optional activity of preparing a three-dimensional model of a particular molecule.
- Plan to show filmstrips:
  "Electrolysis," Set 1 (Black and White) S-67
  "What are Elements and Compounds?" (Set 1 (Color) S-104
  "Crystals," Set 1 (Black and White) S-94
- See yellow box collection of science filmstrip collection in your department:
  "Shapes and Properties of Molecules" "Sizes and Shapes of Molecules"
- Plan to show film "Chemical Change" (12 minutes, Color) Fsd 541.39-1.

PLANNING AHEAD

- Review references on chemical bonding and structural formulas
- Collect molecular model sets for use in demonstrating bonding
- Collect information and prepare cut outs for the flannel board to demonstrate bonding
- Collect cardboard and thumbtacks for student activity in chemical bonding

BROADENING "CONTENT HORIZONS"

Teacher References:

Keenan, and Wood. General Chemistry, 2nd Edition. New York: Harper Bros., 1961.

Selwood, P. W. General Chemistry, 3rd Edition. New York: Henry Holt Co., 1959.

Sienko, and Plane. Chemistry, 2nd Edition. New York: McGraw-Hill, 1961. (Title III - Collection)

Boylan, Brownlee, Fuller, Hancock, Sohon, and Whitsit. Elements of Chemistry. Boston: Allyn and Bacon, Inc., 1962.

Student References:

Fullman, Robert L. "The Growth of Crystals," Scientific American, (March, 1951)

Holden, A., and P. Singer. Crystals and Crystal Growing. New York: Doubleday, 1950.

Watt, George. Basic Concepts of Chemistry. New York: McGraw-Hill, (Title III - Collection)

Beeler, N. F., and F. M. Branley. Experiments With Atomics. New York: Thomas Crowell Co., 1954.

Textbook References:

Smith, Ella Thea. Exploring Biology, 5th Edition. pp. 58-63.

Moon, Otto, and Towle. Modern Biology. pp. 46-52.

DIFFUSION BY MEANS OF CHAOS MACHINE

PURPOSE

To demonstrate the random movement of molecules as in brownian movement

ACTIVITY MATERIALS

Wooden box at least two feet on each edge
Chicken wire mesh
Clear plastic sheets or glass plate
50 to 100 ping pong balls
Heavy duty fan (at least ½ horsepower)

WHAT TO DO

*Mount fan so that the blades will rotate in a horizontal fashion. Divide wooden box into two compartments with fan in lower half. Spread chicken wire mesh directly above fan. Place 50 to 100 ping pong balls on the wire mesh directly over fan. Enclose this entire area with clear plastic or glass.

DISCUSSION

After fan begins to rotate, what happens to the ping pong balls? Is there any pattern to this movement? If we place several dark-colored ping pong balls into the machine are you able to describe the movements?

When fan is turned on, students can see the balls in a chaos of random collisions, varied speeds, and indeterminate directions of motions. The dark-colored balls tend to accentuate the erratic movements of brownian motion.

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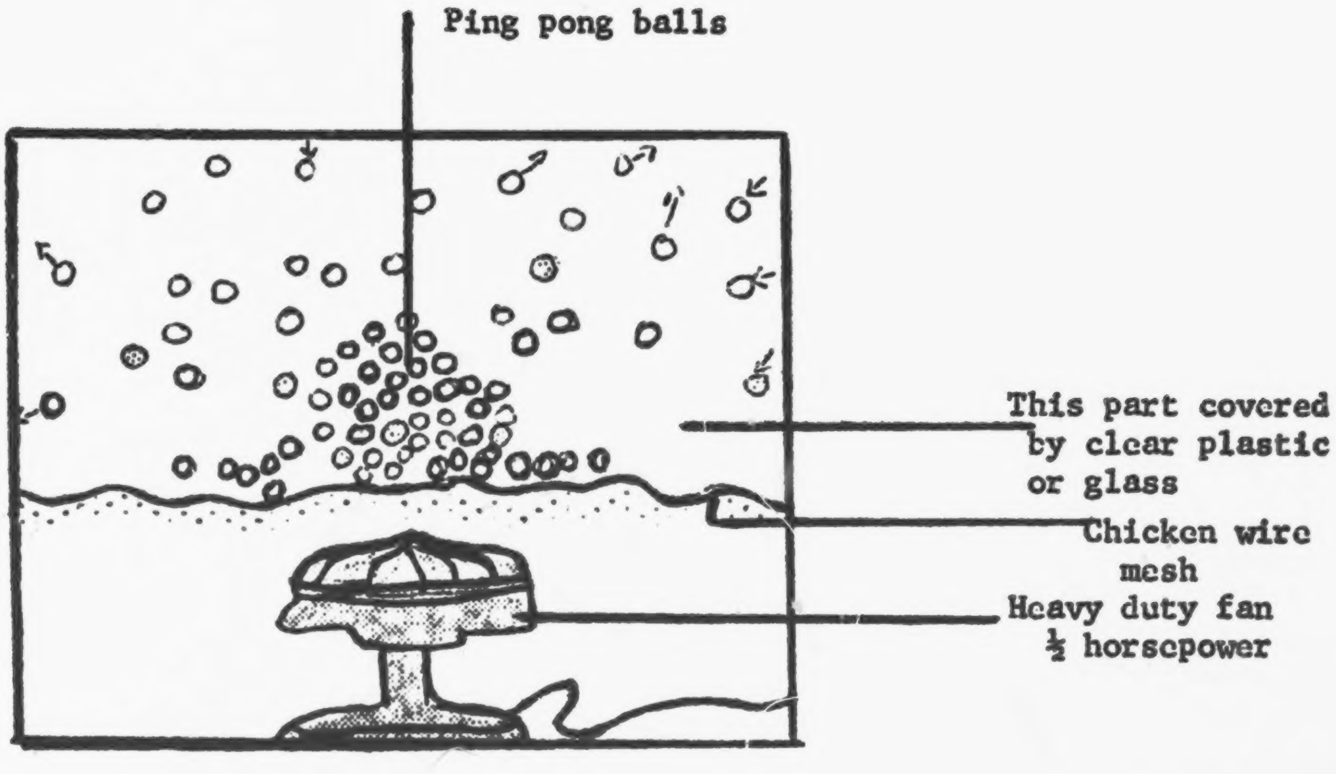
*Joseph, Brandwein, Morholt, Pollack, and Castka. Teaching High School Science: A Sourcebook for the Physical Sciences. New York: Harcourt, Brace, and World, 1961. p. 8, Section 1.2d (This has been adapted from reference given) (Reprinted with permission of the publisher.)


Ping pong balls
This part covered by clear plastic or glass
Chicken wire mesh
Heavy duty fan ½ horsepower

CHANGES - PHYSICAL AND CHEMICAL

PURPOSE

To demonstrate the difference between a physical and chemical change and also the difference between a mixture and a compound

ACTIVITY MATERIALS

Sulfur
Iron filings
Filter paper
Magnets

WHAT TO DO

Students pour sulfur powder on one piece of filter paper and iron filings on another piece of filter paper. One student of the pair passes a magnet through the sulfur powder and then passes the magnet through the iron filings. Student notes what happens to each. Sulfur and iron filings are mixed together and the student passes magnet through the two chemicals. What observations are noted in this activity? What is the combination of iron and sulfur called? Why?

Mix about 4 grams of sulfur to about 6 grams of iron filings in a pyrex test tube. Heat this mixture until the contents glow. Remove the test tube and break it by immersing it in cold water or by covering it with a towel and hitting it against a stone surface with a hammer What is the appearance of the material now? How does this substance compare with the mixture before heating? What is this combination called now?

Joseph, Brandwein, Morholt, Pollack, and Castka. Teaching High School Science: A Sourcebook for the Physical Sciences. New York: Harcourt, Brace, and World, 1961. pp. 28-30.

UNIT ONE: FOUNDATIONS OF LIFE

PURPOSE

To demonstrate the difference between a physical and chemical change and also the difference between a mixture and a compound

ACTIVITY MATERIALS

Wood splints
Paper
Piece of cloth
Scissors
Ice cube
Brom thymol blue
Limewater
Dry ice

WHAT TO DO

Student tears a piece of paper, cuts a piece of cloth, breaks a wood splint in two. Class is asked to decide whether a physical or chemical change has taken place.

Display several ice cubes in a beaker. Remove some of the ice cubes and heat in a pyrex beaker until ice has melted into water. Pour some of this water into another beaker and continue to heat water until boiling and steam is evaporating. What kind of changes have been made, physical or chemical? What explanation can be made of each phase: ice, water, steam?

Carefully place dry ice into a beaker (use gloves or tongs when handling dry ice). Pour the steam-like gas into a container of limewater or brom thymol blue. What happens to the limewater or brom thymol blue? Why? Is this a chemical or physical change?

BROWNIAN MOVEMENT - "SMOKE BOX"

PURPOSE

To demonstrate brownian movement of molecules

ACTIVITY MATERIALS

India ink or carmine red powder
Microscope
Glass slide
Water

WHAT TO DO

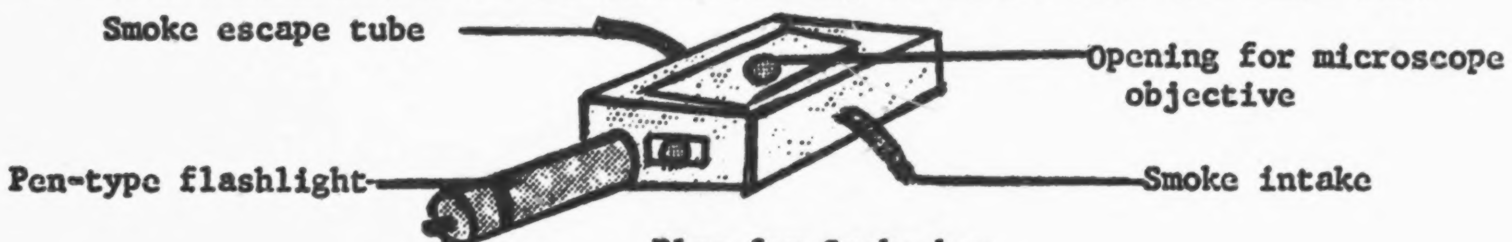
Student prepares slide by adding a pinch of carmine or India ink (pollen grains, or sawdust) to a drop of water on a glass slide. Examine under low power of the microscope. The specks of material are in constant motion. These microscopic particles are set in random motion by collisions with invisible molecules of water.

ACTIVITY MATERIALS

Small match box
Cellophane tape
Light beam source
Smoke source
Microscope
Tubing

WHAT TO DO

Using a small match box, prepare a smoke box to illustrate brownian movement. Cut a hole in the top of the match box for the objective of the microscope. Cover this with scotch tape. Cut a hole in one side of the box to admit a beam of light from the pen-type flashlight. Cover this hole with scotch tape. Make a hole on the opposite side of the match box for a lead-in tube for smoke and on the side opposite this tube make a hole for a lead-out tube for the escape of smoke. See diagram below. Instead of smoke, a pinch of very fine arrowroot starch powder or microballoons* may be dusted into the smoke box.



Plan for Smoke-box

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*Purchased from Bakelite Co., Division of Union Carbide Corp., 30 E. 42 Street New York, New York.

DIFFUSION

PURPOSE

To demonstrate diffusion of molecules

ACTIVITY MATERIALS

Oil of cloves (peppermint or strong perfume)
Glass dish (petri dish or watch glass)
Several small beakers (or graduated cylinders)
Copper sulfate crystals (small)
Potassium permanganate crystals
Ink

WHAT TO DO

Test 1

Fill a beaker ½ full of water. Drop a crystal of copper sulfate in at a given time. Students record time it takes for the crystal to diffuse. Since this process takes a longer period than other diffusions, it is best to start this test first and then go on with other tests.

Test 2

Fill a beaker ½ full of water. Drop several crystals of potassium permanganate into it. What happens? Why?

Test 3

Fill a beaker ½ full of water. Add several drops of ink to the water. Do not stir or agitate the water. What happens? Why?

Test 4

Add several drops of oil of cloves (peppermint or perfume) to a watch glass or petri dish. Allow the drops to diffuse. Ask the class how many of them can detect an odor. When the odor has reached the last row of students, ask students to explain how the odor can be detected by most of the class if the oil of cloves is in a watch glass at the front of the room. Determine the amount of time it takes for the molecules to travel throughout the room. Students should note time when first class member detects odor. Do not tell students the odor or scent being used in the experiment.

Save the beaker with the copper sulfate crystal for several days. Have students note the time it has taken for diffusion of molecules of copper sulfate. Save beakers for all of the first three tests for at least two days. Show them to the class again for further discussion and observations.

DIFFUSION

PURPOSE

To demonstrate an important process operating in living and non-living systems--principle of diffusion

ACTIVITY MATERIALS

Chloroform
Ether
Methylene blue
Burette tube (50 cc)
Small bore pipette
Cork to fit burette tube
Ringstand
Burette clamp
Wax pencil

WHAT TO DO

Place chloroform in burette tube (about 20 cc). With a pipette gently flow water colored with methylene blue (0.5 cc) onto the chloroform. Using the same pipette, gently flow ether onto the colored water (20 cc). Tightly stopper the tube and allow it to stand for a few minutes until the colored water forms a clear cut layer between the ether and chloroform. Mark the level of the water on the tube with a wax pencil. Attach tube to ringstand with burette clamp and set the demonstration where it will not be disturbed but may be observed by students over a period of several days.

What has happened to the water level? Why?

TEACHER REFERENCE

Within a few days it will be noted that the water level is higher than the original mark. The water layer is more permeable to ether than to chloroform.

Reference: Miller, and Blaydes. Methods and Materials for Teaching Biological Science. New York: McGraw-Hill, 1938. p. 328.

MOLECULE BUILDING

PURPOSE:

To aid students in learning about the structure of molecules so that they may better understand cellular physiology.

ACTIVITY MATERIALS

For flannel board "kits"
Construction paper of various colors
Scissors
Flocking paper for backing
Individual flannel boards
Instruction on molecule designs (ditto)

WHAT TO DO

For flannel board "kits":
For molecule designs listed on next page, have student (or teacher may prepare these in advance) cut various circles for simple molecules construction. Use orange circles about 1/2" or 3/4" in diameter to represent carbon atoms; yellow circles of similar size to represent oxygen atoms; green circles about ¼" in diameter to represent hydrogen atoms. (The diameters of circles are suggested diameters...any or all dimensions may be altered to suit space on individual flannel boards). Use toothpicks, yarn or other substances to represent the bonds connecting the atoms.

ACTIVITY MATERIALS

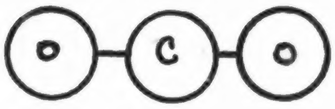
Polystyrene (styrofoam) balls of various sizes
Cork balls of various sizes and colors
Pop-it beads of various colors
White shellac
Dry tempera of various colors
Pipe cleaners, wood dowels, or toothpicks

WHAT TO DO

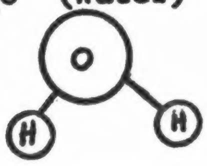
For building three-dimensional models:
For molecule designs listed on next page, have student prepare a simple model of a molecule by using various sizes of cork balls painted in a variety of colors (styrofoam balls are best for models that will remain permanently put together). Toothpicks, wood dowels, or pipe cleaners can be used as bonds. (If preferred, the teacher may prepare these molecules in advance or during a class demonstration.) For more information on building permanent models of molecules see this excellent reference: Sanderson, R. T. Teaching Chemistry With Models. Princeton, New Jersey: D. Van Nostrand, 1962.

Molecule designs listed on the page do not attempt to show scale of size, angles of bonds, or length of distances between atoms. More information about various molecules are given in reference cited on page 34.

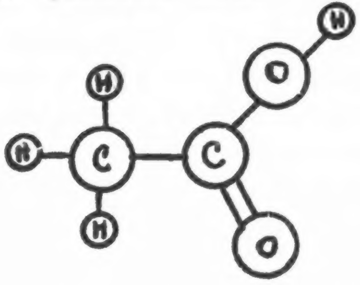
CO_2 (Carbon Dioxide)



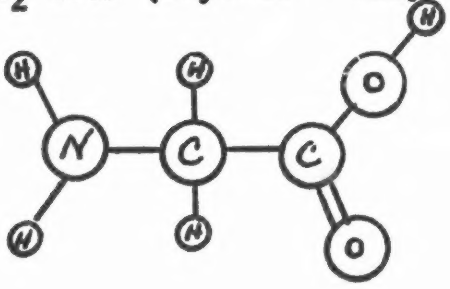
H_2O (Water)



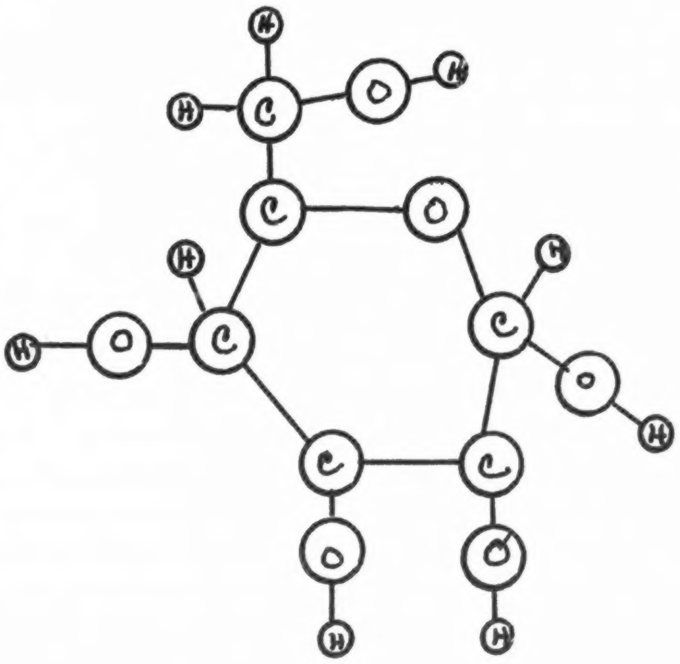
CH_3 COOH (Acetic Acid - Simple Fat)



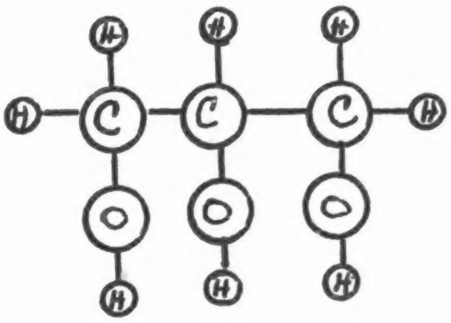
NH_2 CH_2 COOH (Glycine - Simple Amino Acid)



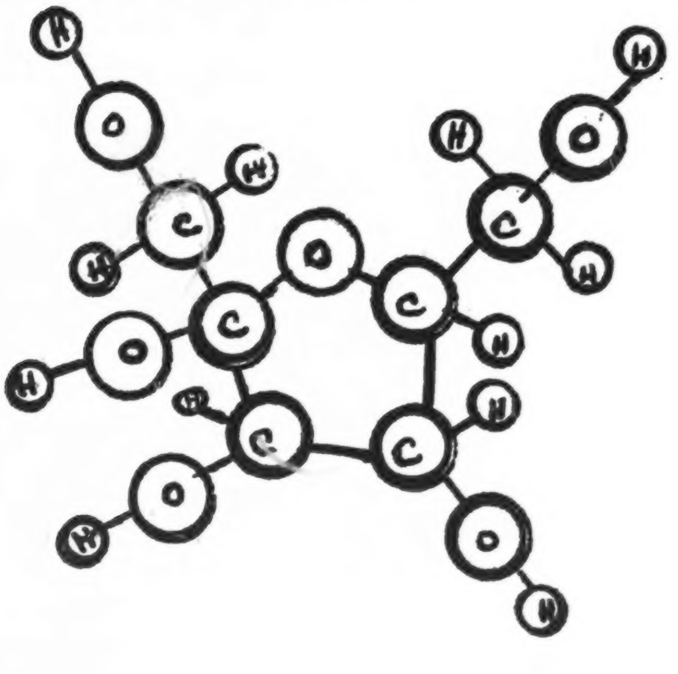
C_6 H_{12} O_6 (Simple Sugar Glucose)



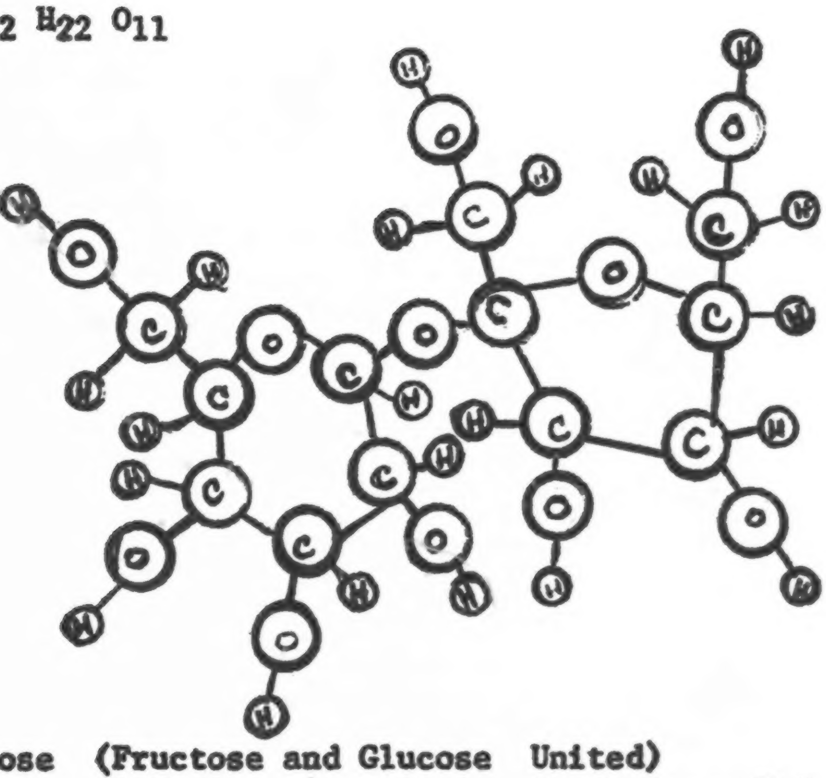
C_3H_5 $(OH)_3$ (Glycerol - Simple Fat)



$C_6 H_{12} O_6$ (Fructose)



$C_{12} H_{22} O_{11}$



Sucrose (Fructose and Glucose United)
$C_6H_{12}O_6 + C_6H_{12}O_6 \quad G_{12}H_{22}O_{11} + H_2O$

MOLECULE BUILDING

PURPOSE

To aid students in understanding the concept of molecule structure by a visual aid ... flannel board

ACTIVITY MATERIALS

Flannel board
Construction paper of various colors
Flocking paper backing
Scissors
Yarn

WHAT TO DO

Prepare cutouts of atoms from construction paper and back each cutout with a small section of flocking paper for better adhesion. Use construction paper or toothpicks, pipe cleaners, yarn, cloth, or other material to represent bonds. Prepare orange circles about 2" in diameter to represent carbon atoms; yellow circles about 2" in diameter to represent oxygen atoms; green circles about 1" in diameter to represent hydrogen atoms. Use other colors to represent other elements as needed for flannel board demonstration.

Start with a simple molecule first, i.e., build a carbon dioxide molecule or a water molecule. Now build some complex molecules of importance in this unit of work. Build some organic molecules, i.e., a simple carbohydrate, amino acid, and fat. Designs for molecules are shown on pages 35-36.

"CARDBOARD" CRYSTALS

PURPOSE

To demonstrate the elements and properties of crystal structure through cardboard models

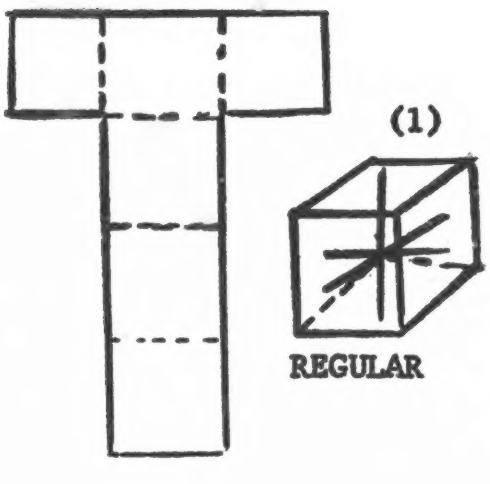
ACTIVITY MATERIALS

- Capillary tube
- Soapy or sudsy water
- Cardboard or tagboard
- Dull knife
- Glue, tape, or rubber cement

WHAT TO DO

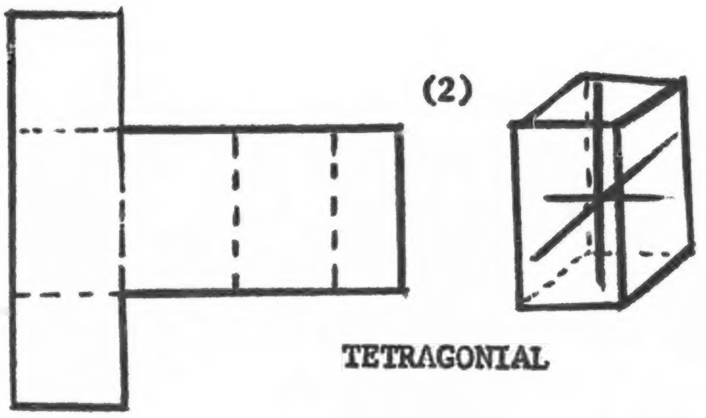
Student blows air through a capillary tube at a uniform pressure, after tube has been dipped beneath the surface of soapy water. A two-dimensional model of a crystal can be seen growing as the little bubbles rise to the surface, attract one another, and come together to form "bubble rafts," each bubble touching six others."*

Students design cardboard cutouts from drawings given below. A representative of each of the main crystal systems can be made by cutting the cardboard into the first initial shape and then folding this cardboard on the dotted lines by using a dull knife to aid in the folding process.



(1)

REGULAR



(2)

TETRAGONIAL

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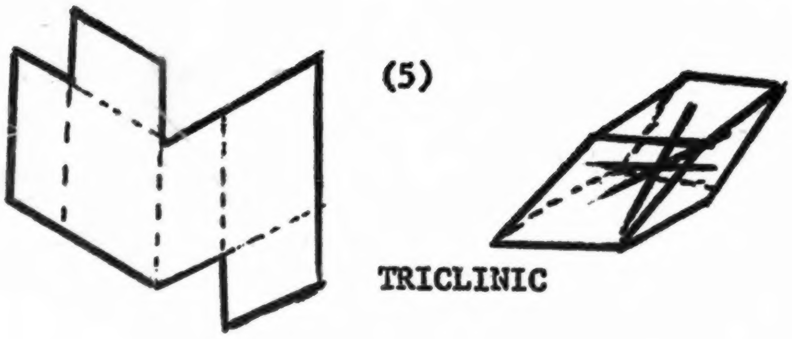
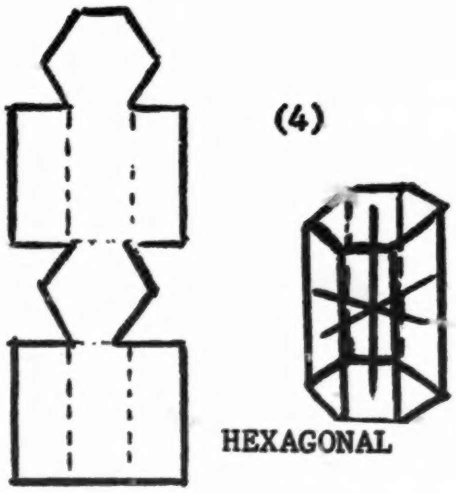
*Joseph, Brandwein, Morholt, Pollack, and Castka. Teaching High School Science: A Sourcebook for the Physical Sciences. New York: Harcourt, Brace, and World, 1961. pp. 119-120.

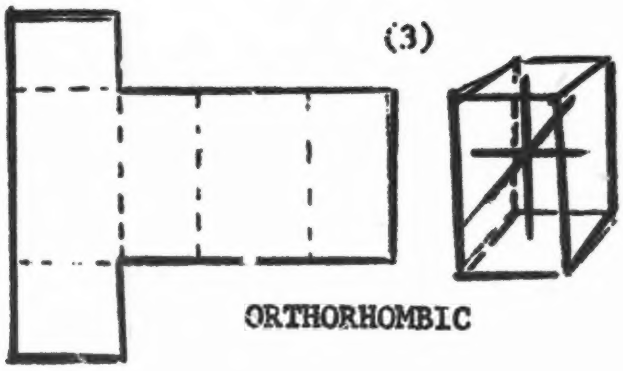
"CARDBOARD" CRYSTALS*


(5)

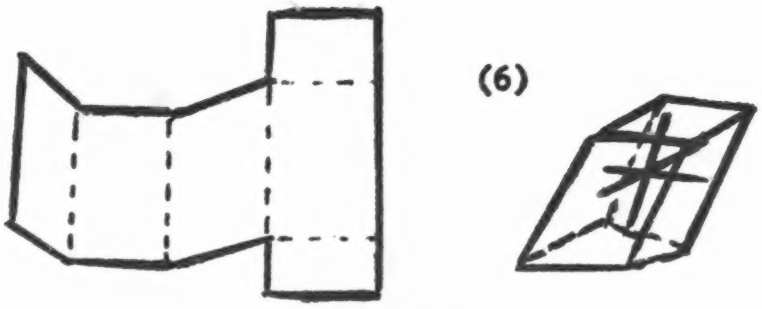
TRICLINIC


(4)

HEXAGONAL


(3)

ORTHORHOMBIC


(6)

MONOCLINIC

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*From:
CRYSTALS AND CRYSTAL GROWING by Alan Holden and Phylis Singer. Copyright © 1960 by Educational Services Incorporated. Reprinted by permission of Doubleday & Company, Inc.

SPLITTING CHEMICAL BONDS

PURPOSE

To demonstrate that energy is needed to separate chemical bonds between two atoms ... electrolysis of water

ACTIVITY MATERIALS

Hoffman apparatus
Two test tubes
Source of 6-8 volt direct current
Dilute sulfuric acid
Water
Wood splints or toothpicks

WHAT TO TO

Fill the Hoffman apparatus with water (distilled) to the mark shown on the diagram below. Connect the electrode wires to the power source (battery). What are the results?

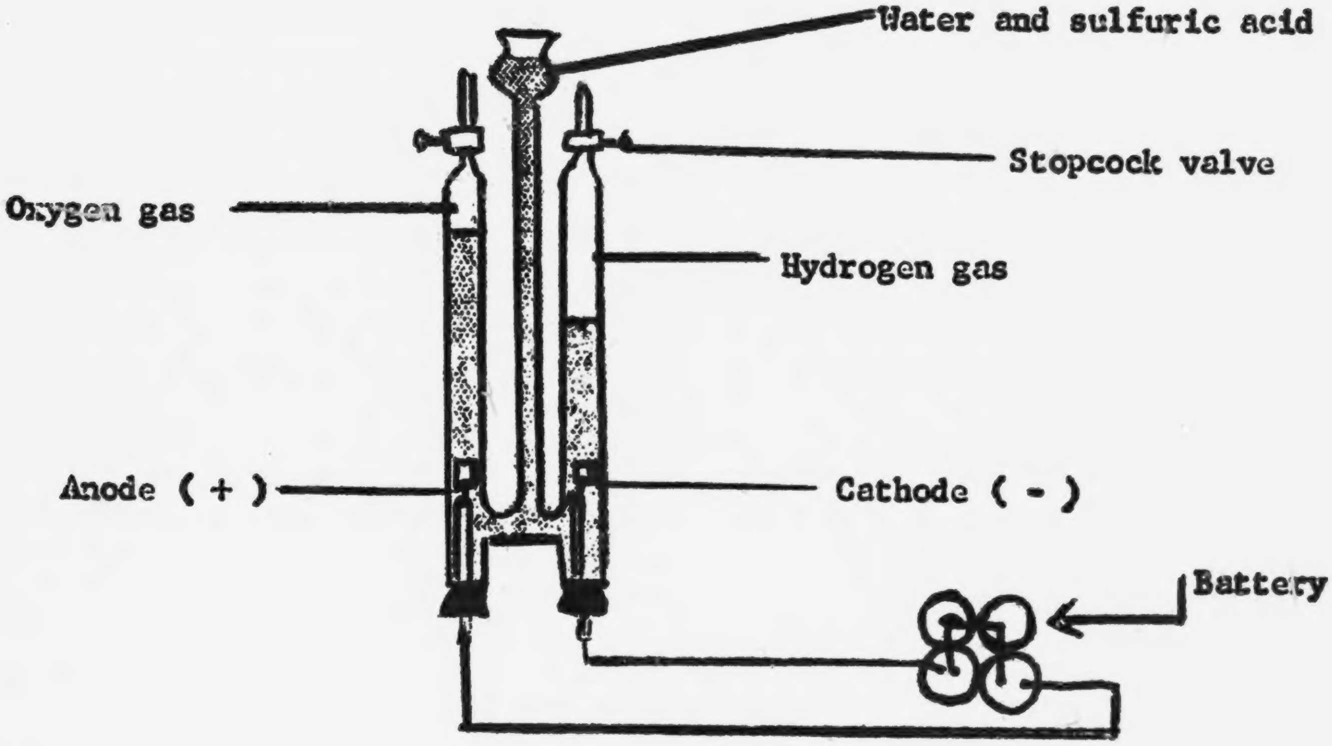
Slowly add a few drops of dilute sulfuric acid to the distilled water in the Hoffman apparatus. Pass the current through the water-acid mixture until there is enough gas in each side tube to fill a small test tube. Note the volume of gas at the anode (+) and at the cathode (-). A noticeable bubbling will occur as the current passes through the water-acid mixture and the water level in the reservoir will begin to fall.

Hold an inverted pyrex glass tube over the side tube which contains the cathode (-). Open the stopcock valve and allow the gas to flow into the test tube. Cover open end of test tube with thumb to prevent the escape of the gas. Place a burning splint to the mouth of the test tube. What happens?

Follow the same procedure for collecting gas from side tube which contains the anode (+). Test gas by inserting a glowing splint. What happens?

Was there any difference in the amount of gas collected in cathode and anode tubes?
What gases are produced by electrolysis of water?
This experiment proves that water is an (element, compound)?
The formula for water is? How does this formula relate to gas collection?

Fliedner, and Teichman. Laboratory Manual for Chemistry - Man's Servant. Allyn and Bacon, 1961. p. 49.


Water and sulfuric acid
Stopcock valve
Oxygen gas
Hydrogen gas
Anode (+)
Cathode (-)
Battery

UNIT ONE: FOUNDATIONS OF LIFE

CONCEPTS TO CONSIDER

Valence of an element is a number which indicates the combining power of an atom in its union with other atoms

The chemical activity of an atom is determined by the number of its outermost electrons

Shells are called principle energy levels. These are subdivided into subshells which are designated by letters s, p, d, and f

Each energy level contains a certain number of electrons which have a certain quantity of energy

The electrons in the outermost shell of an atom are commonly called valence electrons

Valence number is a number that shows how many electrons are gained, lost, or shared when an atom joins another atom

Chemical bonding is the exchange or sharing of one or more electrons between atoms which unite in chemical reactions

Formulas consist of symbols showing the number and kind of atoms present

Formulas that represent the actual number of atoms present are called molecular formulas

Formulas that represent an indefinite number of atomic groups are called empirical formulas (these show proportion of the atoms in a compound)

TEACHING APPROACH (Methods and Activities)

Discuss briefly and review electron energy levels
- Review the parts of an atom using the flannel board and emphasize the importance of energy levels especially those electrons in the atom in the outermost shell
- Students prepare a chart showing the energy levels of various elements (atoms)

Discuss Bonding
- Demonstrate using the flannel board how atoms are able to combine with other atoms to form molecules
- Emphasize the mechanism of bonding by an explanation of COVALENT and IONIC bonding
- Demonstrate these two types of bonding by using the electron dot formula on the flannel board
- Students copy electron dot formula for several compounds using references, learning to write and understand other formulas that may be given
- Students make models showing covalent bonding by use of thumb tacks and cardboard
- Students learn to change electron dot formula into structural formula with help from teacher

- Students practice writing structural formulas in their notebooks. Write structural formulas for the three-dimensional models displayed in and around the room.
- Students discuss the need to learn about structural formulas instead of relying wholly on the empirical formula.

DEPTH PROBE

- BONDING IN MOLECULES, p. 43 (Average Student Basic Activity). Building molecules to demonstrate bonding. Students work in pairs.

- ELECTRON DOT AND STRUCTURAL FORMULAS, p. 44 (Average Student Basic Activity). Learning to write structural formulas from the electron dot method. Teacher or student demonstration.

"TOOLS" FOR EXTENDING CONCEPTS

- Prepare a bulletin board display to emphasize the bonding principle, showing the difference between COVALENT AND IONIC BONDING.
- Prepare a bulletin board entitled "UP AND ATOM," showing the various energy levels of different elements (atoms).
- Prepare another bulletin board entitled "IT'S THE VALENCE THAT COUNTS," showing covalent bonding and ionic bonding.
- Preview filmstrips "The Chemical Bond," set 1 S-93; "The Chemical Formula," Set 1, S-60; and "Balancing Equations By Electron Transfer," Set 1, S-140; show selected frames from these filmstrips.
- (Optional activity) Assign students to find the structural formulas for guanine, cytosine, thymine, and adenine.
- (Optional activity) Some students may want to prepare permanent models, using source Teaching Chemistry with Models. R. T. Sanderson. (D. Van Nostrand Company, Princeton, New Jersey, 1962).

PLANNING AHEAD

- Collect reference materials from the school library, such as Great Experiments In Biology, Gabriel and Fogel; Case Studies in the History of Science, Conant, et al.
- Read in Outline Course of Study Biology 1, section on PATTERNS IN TEACHING METHODS, p. 44, to review points about the "How to Teach by Case Study Method."
- Prepare equipment and materials for experiment in spontaneous generation.
- Prepare necessary ditto sheets for use in section on ORIGIN OF LIFE, see p. 59.
- Locate book World We Live In (Title III - Collection).

- Plan to reserve a class set of microscopes and materials for a three day lesson on its use
- Collect and reserve a class set of meter sticks and plastic rulers
- Collect or assign students the task of bringing half-tone photographs from magazines or newsprint for microscopic study
- Locate beef bouillon or nutrient broth
- Prepare glass tubing for experiment, p. 56
- Locate p^H test paper, litmus paper (Red and Blue)

BROADENING "CONTENT HORIZONS"

Teacher References:

- Clapp, L. Chemistry of the Covalent Bond. San Francisco: Freeman Pub., 1957.

- Leicester, H., and H. Klickstein. Sourcebook in Chemistry. Cambridge, Mass.: Harvard University Press, 1956.

- Sanderson, R., and W. Bennett. A Laboratory Manual for Introduction to Chemistry. New York: Wiley Pub., 1959.

- Sanderson, R. T. Teaching Chemistry With Models. Princeton, New Jersey: D. Van Nostrand Company, 1962.

- Joseph, Brandwein, Morholt, Pollack, and Castka. Teaching High School Science: A Sourcebook for the Physical Science. New York: Harcourt, Brace and World, 1961.

Student References:

- Snell, C., and F. Snell. Chemistry Made Easy. New York: Chemical Pub. Co., 1959.

- Sienko, and Plane. Chemistry, 2nd Edition. New York: McGraw-Hill, 1961. (Title III - Collection)

- Bradbury, McGill, Smith, and Baker. Chemistry and You. Lyons and Carnahan, (Title III - Collection)

Textbook References:

- Smith, Ella Thea. Exploring Biology, 5th Edition. pp. 59-70.

- Moon, Otto, and Towle. Modern Biology. pp. 41-48.

BONDING IN MOLECULES

PURPOSE:

To demonstrate the bonding principle in clear and easy terms

ACTIVITY MATERIALS:

Thumbtacks, or map tacks (various colored heads)
Cardboard circles

WHAT TO DO:

Students prepare two atoms that will combine by sharing electrons to demonstrate covalent bonding. Prepare two circles of equal size showing one electron on each circle in its outermost orbit. These circles will represent two atoms of hydrogen. Prepare another circle to represent one atom of oxygen but this atom will show six electrons in its outermost orbit. Now combine the oxygen atom with the two hydrogen atoms to show covalent bonding as in figure 1 below:

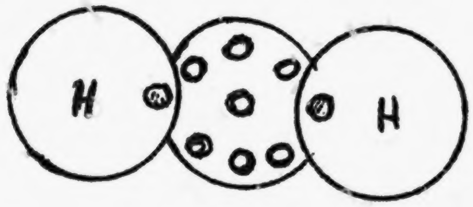
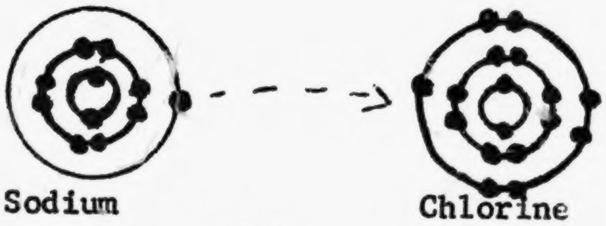


figure 1. H_2O

Students prepare two circles as shown below in figure 2 to show ionic bonding. Check references for more examples of these two types of bonding.



NaCl

figure 2.

ELECTRON DOT AND STRUCTURAL FORMULAS

PURPOSE

To aid the student in understanding the concept of electron dot and structural formulas by a visual aid, the flannel board

ACTIVITY MATERIALS

Flannel board
Construction paper of various colors
Flocking paper backing
Scissors

WHAT TO DO

Prepare circles of various colors for the designs listed below. Cut out the letters in the same colors of construction paper.

Show bonding of the following:

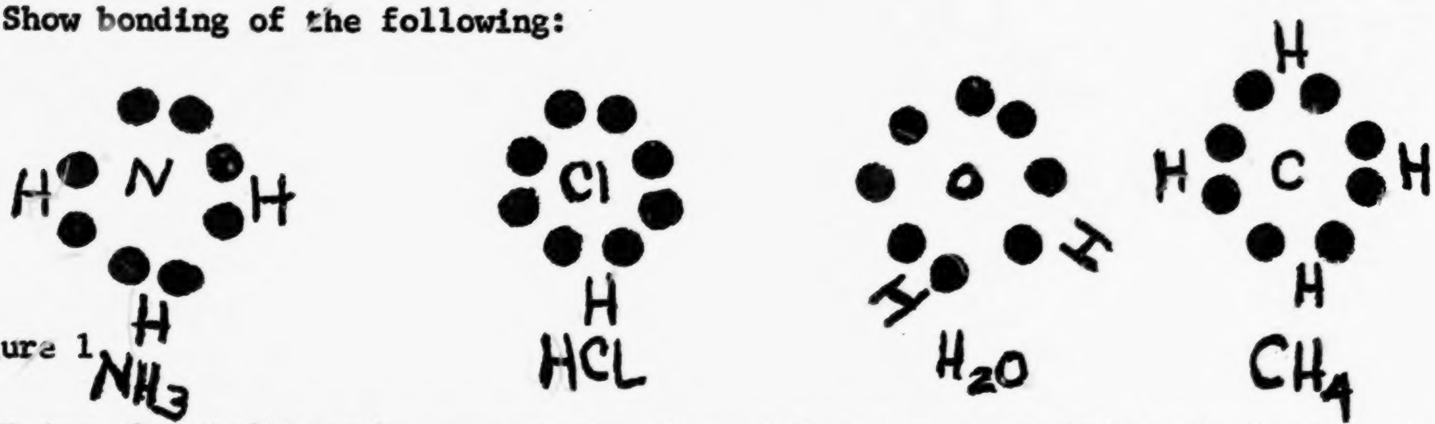


figure 1

Using the chalkboard, convert the flannel board demonstration of electron dot formulas into structural formulas:

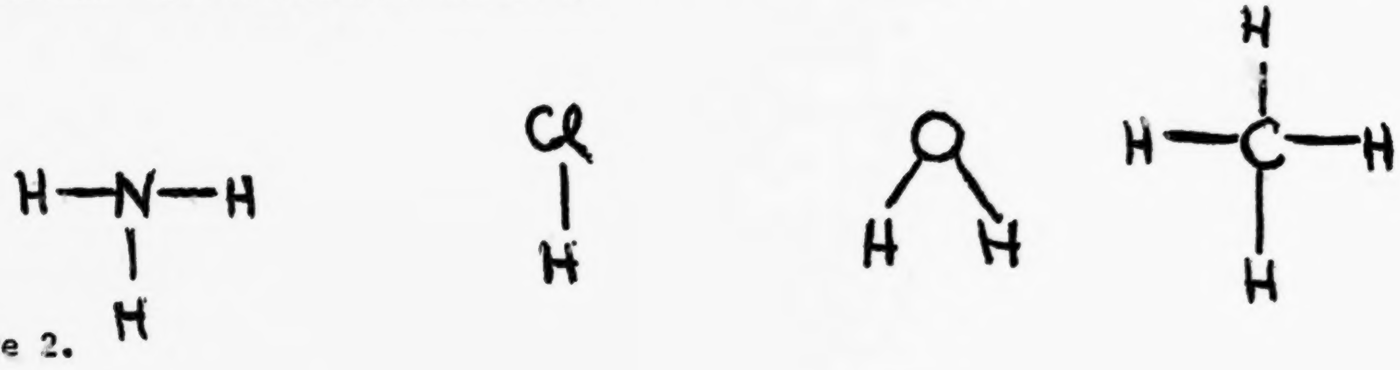


figure 2.

UNIT ONE: FOUNDATIONS OF LIFE

CONCEPTS TO CONSIDER

A hypothesis suggesting the origin of life assumes that inorganic substances from the primitive earth's atmosphere combined through energy of lightning and ultraviolet radiation formed complex organic molecules. These molecules were capable of self duplication and therefore were considered to be alive (Heterotroph)

Cell is the unit of structure in living organisms

All cells come from previously existing cells

Cell is the unit of function in the living organism

A microscope is, of necessity, very delicate and built to high precision, hence it must be handled with care and understanding in order to obtain desired results

The microscope is a basic tool of the biologist

Without the microscope whole areas of biology could never have been developed

A microscope contains one or more lenses which bend light and in this way magnify an object

Objects viewed through the microscope must be small and sufficiently thin to allow light to pass through

Microscopic investigations are most successful when the student has learned the use of the microscope by an outlined procedure

TEACHING APPROACH (Methods and Activities)

Discuss and review the "dust particle theory" of the origin of life, heterotroph hypothesis, spontaneous generation.

- Students make a written comparison of the various theories concerned with origin of life after class discussion
- Students give reports on a variety of topics of interest and background setting for topic on origin of life; i.e., chemical evolution, evolution of the universe, steady state theory, etc.
- Students perform experiments demonstrating conclusions concerning spontaneous generation
- Discuss and review the work of Redi, Needham, Tyndall, Pasteur, and Spallanzani (Develop material through Case-Study Method .)*
- Discuss present theories about Pasteur's concept of spontaneous generation and theories about spontaneous generation today in view of Miller-Urey experiments
- Demonstrate coacervates through group work. See p. 50.

*See Biology I Outline Course of Study, page 44.

- Prepare excerpts or summarize material from heterotroph hypothesis in A. Oparin's Origin of Life, New York: MacMillian, 1938. (Dover Book) 1960. Students read material and make a brief outline of the most important points in this theory.
- Give students a ditto of chart entitled EARLY STAGES IN THE EVOLUTION OF LIFE, p. 59.
- Display and discuss the book World We Live In (Title III - Collection)

Discuss the cell theory and the use of the microscope in its study.

- Prepare ditto copies of excerpts of some of the writings of Schleiden, Schwann, Leeuwenhoek, and Robert Hooke. Students read these accounts and become aware of the way scientists work and how scientific materials and knowledge accumulate and form a broad base for succeeding information.

- Demonstrate the use of the microscope and use of the parts of the microscope.
- Students learn microscopic techniques.
- Students review metric system measurements in connection with microscopic measurements.
- Students learn techniques of mounting and staining living plant and animal tissues.

DEPTH PROBE

- AN ANALOGUE--COLLOIDAL PARTICLES--COACERVATES, pp. 50-51. (Average Student Basic Activity). Understanding about coacervates and observing them under a variety of pH ranges. Students work in pairs or groups.

- RECENT EXPERIMENTS ON THE HETEROTROPH HYPOTHESIS, pp. 53-55. (Average Student Basic Activity). Gathering facts about the heterotroph hypothesis and drawing some conclusions based on data and graph. Student homework assignment.

- DISPROVING SPONTANEOUS GENERATION THROUGH CLASSICAL EXPERIMENTATION, pp. 56-58. (Average Student Basic Activity). Demonstrating through classical experiments that organisms arise from previously existing organisms. Group work or class demonstration.

- EARLY STAGES IN THE EVOLUTION OF LIFE, p. 59. (Average Student Basic Activity - Optional). A ditto sheet for students. Student homework assignment.

- REVIEWING METRIC MEASUREMENT, p. 60. (Average Student Basic Activity). Reviewing the metric system before learning about microscopic measurements. Students work in pairs.

- RULES ON USING MICROSCOPE, pp. 61-64. (Average Student Basic Activity). Learning the use and parts of the microscope. Learning to prepare slides. Students work in pairs.

- PREPARATION AND OBSERVATION OF SLIDES, pp. 65-67. (Average Student Basic Activity). Techniques of slide preparation. Students work in pairs.

- MICROSCOPIC MAGNIFICATIONS, p. 68. (More able Students - Basic). How small is small? Student homework assignment.

"TOOLS" FOR EXTENDING CONCEPTS

- Prepare a bulletin board which shows the parts of the microscope.
- Assign students to report about Leeuwenhoek, Schleiden, Schwann, et al.
- Plan to show filmstrips:
    - "Antony Van Leeuwenhoek," Set 2, S-102 or Blue Box--Science filmstrip collection, Science Department.
    - "Earth Is Born," Set 1, S-78

- Encourage a student to read about the Miller-Urey experiments and to recreate this experiment in the classroom.
- Encourage some students to prepare vaseline mounts for viewing microscopically.
- Allow some students to compare the use of the microscope to the stereomicroscope.
- Encourage some students to prepare three-dimensional models of microscopic material viewed in class.
- Display the best drawings of students on the bulletin board.

PLANNING AHEAD

- Collect pictures of photomicrographs of viruses. (Life Magazine and Scientific American).
- Assign students the task of bringing in pond water in large jars.
- Assign students materials to be brought in for laboratory on microorganisms. See pp. 77-79.
- Student groups may want to build three-dimensional models of virus.
- Prepare flannel board demonstration on the parts of a virus.

- Prepare a bulletin board that will show the difference between a virus, Rickettsial body, and bacteria
- Collect some cigarette tobacco for laboratory experiment on virus. See p.
- Gather materials for growing slime molds
- Prepare a flannel board demonstration on the major points of the slime mold life cycle

BROADENING "CONTENT HORIZONS"

Teacher References:

- Gabriel, M., and S. Fogel. Great Experiments in Biology. Engelwood Cliffs, New Jersey: Prentice-Hall, 1955.
- Conant, J. B. Case Studies in the History of Science. Cambridge, Mass.: Harvard University, 1950-1953.
- Conant, J. B. On Understanding Science. New Haven, Conn.: Yale University, 1947. Mentor Books, New York, 1952 (Paperback 35¢) (Title III - Collection)
- Gray, Peter. Handbook of Basic Microtechnique. New York: McGraw-Hill, 1958.
- Weisz, Paul. Science of Biology. New York: McGraw-Hill, 1958.
- Simpson, Pittendrigh, and Tiffany. Life: An Introduction to Biology. New York: Harcourt-Brace, 1957. (Title III - Collection)

Student References:

- Boyden, Alan. "Are There Any 'Acellular Organisms'?" Science, (Jan. 25, 1957), pp. 155-156.
- Corrington, Julius. Exploring With Your Microscope. McGraw-Hill, 1957. (Title III - Collection)
- Jones, Spencer. Life On Other Worlds. Mentor Books.
- Adler, Irving. How Life Began. Signet Books.

UNIT ONE: FOUNDATIONS OF LIFE

- Wald, George. "The Origin of Life," Scientific American, (Aug. 1954)
- Urey, Harold. "The Origin of the Earth," Scientific American, (Oct. 1952)
- Dobell, Clifford. Antony Van Leeuwenhoek and His "Little Animals," New York: Dover Books
- Shippen, K. B. Men, Microscopes and Living Things. New York: Viking Books, 1955.
- "Lives In Science," Scientific American, Rockefellar Center, New York: Simon and Schuster, 1957. (Title III - Collection)

AN ANALOGUE - COLLOIDAL PARTICLES--COACERVATES

PURPOSE

To understand something about coacervates (Oparin's hypothesis suggests accumulations of colloidal particles) and observe them under a variety of pH ranges

ACTIVITY MATERIALS

Powdered gelatin (protein)
Water
Gum arabic in water (carbohydrate)
0.03 N HCl
Pipettes

pH test paper
Test tubes
Microscope slides
Cover slips
Microscopes

WHAT TO DO

Dissolve powdered gelatin in water. Mix 6 ml of dissolved gelatin and 4 ml of gum arabic in a test tube.

Test the pH*(see definition) of the mixture by placing a drop on a microscope slide. Tear off about 3 cm strip of pH test paper and dip the torn end into the liquid mixture. Compare the color on the paper and the dispenser after 15 seconds. Examine the drop of tested liquid under the low power objective of the microscope after adding cover slip.

Carefully add 0.03 N* HCl solution (see definition) drop by drop to the test tube containing the liquid mixture. After the addition of each two drops of acid solution, shake the test tube well, and then put a drop on a slide, cover it and observe it under low power objective of the microscope.

When the material turns cloudy take another pH reading. At this point, carefully observe a drop on a slide for the presence of coacervates. Continue to add the acid solution and after each second drop observe. When your liquid becomes clear again make your last observation and pH reading. If you did not observe coacervates, repeat the procedure for you may have added acid too rapidly.

If directed, observe the living amoeba under the microscope and note the differences and similarities between this and the coacervate droplets. (Optional)

Adapted from Laboratory Manual, BSCS Blue Version, pp. 93-94.

*Definitions on page 52.

QUESTIONS

1. Give a description of the coacervates?

2. A combination of the gelatin and gum arabic might be similar to what part of the heterotroph hypothesis (Oparin's hypothesis)

3. Why might the coacervates droplets have disintegrated after adding more acid?

4. Careful experimentation has shown that coacervates formed in a similar manner have been capable of decomposing starch to sugar. What possible support has this given to the origin of life as expounded by Oparin?

5. What obvious property does the ameba have that was lacking in the coacervates? (Optional)

*NORMAL AND MOLAR SOLUTIONS

N - Abbreviated to mean one normal solution. 1 gram equivalent of a substance in 1 liter of solution will result in a normal solution of that compound. In general, a normal solution is prepared by dissolving in 1 liter of solution a quantity of the acid, base, or salt determined in the following way:

$$\frac{\text{number of grams required for 1 M solution}}{\text{number of equivalent to 1 H in each molecule}}$$

or

$$\frac{\text{molecular weight of substance in grams}}{\text{valence}}$$

For instance a molar solution of HCl (1 M) would contain its molecular weight in grams in 1 liter of solution (36.5 in 1 liter of solution = 1 M HCl)

For dilutions of a molar solution such as 0.1 M HCl (36.5 X 0.1 = 3.65 gm per liter of solution 0.1 M HCl)
(0.03 X 36.5) = 1.09 gm in a liter of solution

---

*pH - Test Paper "In studies of biological materials, a knowledge of the amount of acidity or alkalinity of the solutions being used is essential. The numerical scale used to express degrees of acidity or alkalinity is called the pH scale. A pH of 7.0 represents a neutral solution; numbers below 7.0 refer to logarithmically increasing degrees of acidity, numbers above 7.0 to logarithmically increasing degrees of alkalinity. The pH of vinegar, for example is 2.25, of water 7.0, and of milk of magnesia is 10.5. The entire scale ranges from 0 to 14, but the majority of living cells prefer a pH close to neutrality." American Biology Teacher, Vol. 22, No. 6 (June 1960), p. 342.

"Three pH indicators that are quite useful in microbiological studies are brom creosol purple, brom thymol blue, and phenol red. The first turns from yellow to purple between pH range of 5.2 to 6.8, the second from yellow to blue between 6.0 and 7.6 and the third from yellow to red between 6.8 and 8.4" Loc. cit.

RECENT EXPERIMENTS ON THE HETEROTROPH HYPOTHESIS

PURPOSE

This activity supports and strengthens class discussion on the heterotroph hypothesis. It will enable the student to work quietly at home on evidence presented in graph form; and from the following data presented below draw conclusions through critical thinking.

ACTIVITY MATERIALS

Ditto sheet of material listed below
Reference material as suggested on p. 49.

PART A

WHAT TO DO

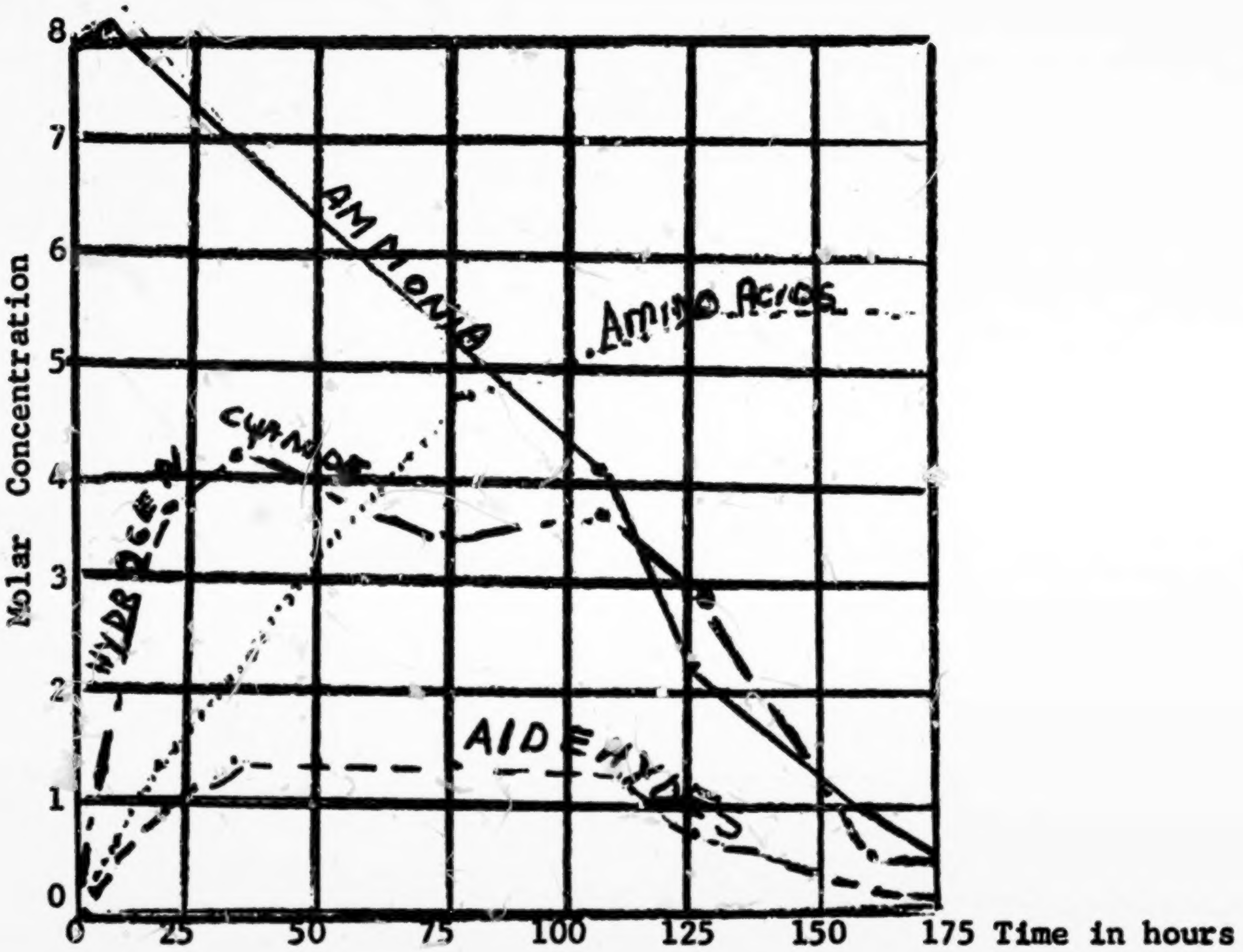
Read the following material and data and answer all questions in sentence form.

INTRODUCTION

"In 1953, using an hypothesis proposed by Urey, Miller, then a graduate student, reported the successful production of amino acids from an atmosphere consisting of ammonia, methane, hydrogen, and boiling water exposed to an electrical discharge. Miller showed that compounds known as aldehydes and hydrogen cyanide are produced and that the amounts of these compounds present account for the observed yield of amino acids."

PROCEDURE

Study graph shown on following page. Note that the horizontal axis shows the time in hours and that the vertical axis shows the molar concentration. You need not be concerned about the precise meaning of "molar concentration;" it is one method of expressing the exact amount of material present in solution.



Concentration of ammonia, hydrogen cyanide, and aldehydes in the U-tube; and amino acids in the flask while sparking a mixture of methane, ammonia, and hydrogen in the Miller apparatus (Adapted from Miller, S., 1960, Formation of Organic Compounds on the Primitive Earth in Aspects of the Origin of Life, edited by M. Florkin, Pergamon Press, New York) (Reprinted with permission of publisher.)

QUESTIONS

1. What happened to the amount of ammonia present as the experiment continued?
2. What happened to the amount of hydrogen cyanide present?
3. What happened to the amount of aldehydes present?
4. What happened to the amounts of amino acid present? Ammonia, hydrogen cyanide, amino acid consist in part of nitrogen. How can you account for the decrease in the amount of ammonia?
5. What hypothesis can you propose for the variations in the amounts of the four substances present as the experiment proceeded?
6. Will production of amino acid cease in a short or a long time? Why?

PART B

"Sidney Fox used the results of Miller's experiment and similar experiments to go one step further. He hypothesized that the primitive earth was fairly hot and that the next step in the creation of life was the production of proteins.

Dr. Fox mixed a number of amino acids found in the proteins of all organisms. He gently heated the mixture of amino acids to above 90°C. After heating the mixture he found several peptides, substances not in the original mixture. Peptides are produced normally by condensation of amino acids. He also found that if he added polyphosphoric acid to the mixture, peptides were produced at the lower temperature of 71°C.

The peptides produced were dissolved in hot water and the solution was allowed to cool. Upon examination he found many microscopic spherical structures which he called microspheres. These microspheres were about the size of spherical bacteria called cocci and were composed of protein like molecules. Dr. Fox found that the peptides he produced were digested by digestive enzymes obtained from animals and that bacteria used the peptides for food. He found that the microspheres shrink in salt water and swell in fresh water."*

QUESTIONS

1. What evidence is available to show that proteins could have been produced on a fairly hot primitive earth?

2. What evidence is available to show that proteins could have been produced on a fairly cool earth?

3. What evidence is available to show that peptides produced experimentally are similar to the peptides found in organisms?

4. In what way do microspheres resemble stalks of celery and potato cores?

5. Why can we only theorize about the origin of life?

6. What evidence, if any, do these experiments present of life on other planets?

---

*Adapted from BSCS, High School Biology, Blue Version - The Laboratory, Exercise 16, Pyrosynthesis, pp. 83-85. (Reprinted by permission of publisher.)

DISPROVING SPONTANEOUS GENERATION THROUGH CLASSICAL EXPERIMENTATION

PURPOSE

To demonstrate through classic experiments that organisms arise from previously existing living things . . . disproving spontaneous generation

ACTIVITY MATERIALS

Fruit flies
Banana culture media
Half-pint bottles or baby food bottles
500 ml of nutrient broth or beef bouillon
Seven flasks (250 ml)
Three pieces of glass tube (7-8 mm in diameters) 8-10 cm long
Five cork stoppers for flasks, three one-hole stoppers
Sealing wax or paraffin
Bell jar

WHAT TO DO

REDI'S EXPERIMENT (See figure 1, on p. 58)

Fill three half-pint bottles with banana media (used in drosophlia culture). Sterilize bottles before media is poured in. Allow bottle #1 to remain uncovered during the experiment. Cover bottle #2 with cheesecloth during the experiment. Cover bottle #3 with cellophane or saran wrap or plastic during the experiment. Place all three bottles under a bell jar. Select a thriving stock jar of fruit flies and invert mouth of bottle into opening on the top of the bell jar. Quickly place a stopper to close the bell jar. Allow this to stand unmolested for at least one week. Students make observations every day. What are the observations after one week? Bottle #1? Bottle #2? Bottle #3?

SPALLANZANI'S EXPERIMENT (See figure 2, p. 58)

Place 70 ml of beef bouillon or nutrient broth into two Erlenmeyer or florences flasks as follows:

Flask #1 Boil broth gently for 15 minutes. Leave this flask uncovered. (CONTROL)

Flask #2 Boil broth gently for 15 minutes. After heating, place cork in flask and seal with paraffin or sealing wax. (EXPERIMENT)

PASTEUR'S EXPERIMENT (See figure 3, p. 58)

Place 70 ml of beef bouillon or nutrient broth into two flasks as follows:

Flask #3 Heat in pressure cooker (autoclave) for 15 minutes at 15 lbs. pressure. Leave this flask uncovered. (CONTROL)

Flask #4 Place a straight glass tubing through a stopper and cork flask. Heat in pressure cooker (autoclave) for 15 minutes at 15 lbs. pressure. (MODIFIED CONTROL)

Flask #5 Place a C-shaped glass tubing through a stopper and cork flask. Heat in pressure cooker (autoclave) for 15 minutes at 15 lbs. pressure. Seal the end of the C-shaped tube with paraffin or sealing wax. (FIRST EXPERIMENT)

Flask #6 Place an S-shaped glass tubing through a stopper and cork the flask. Heat in the pressure cooker (autoclave) for 15 minutes at 15 lbs. pressure. Seal edges with wax or paraffin. Do not attempt to seal the opening of the glass tube. (EXPERIMENT - FINAL)

OVER-ALL CONTROL

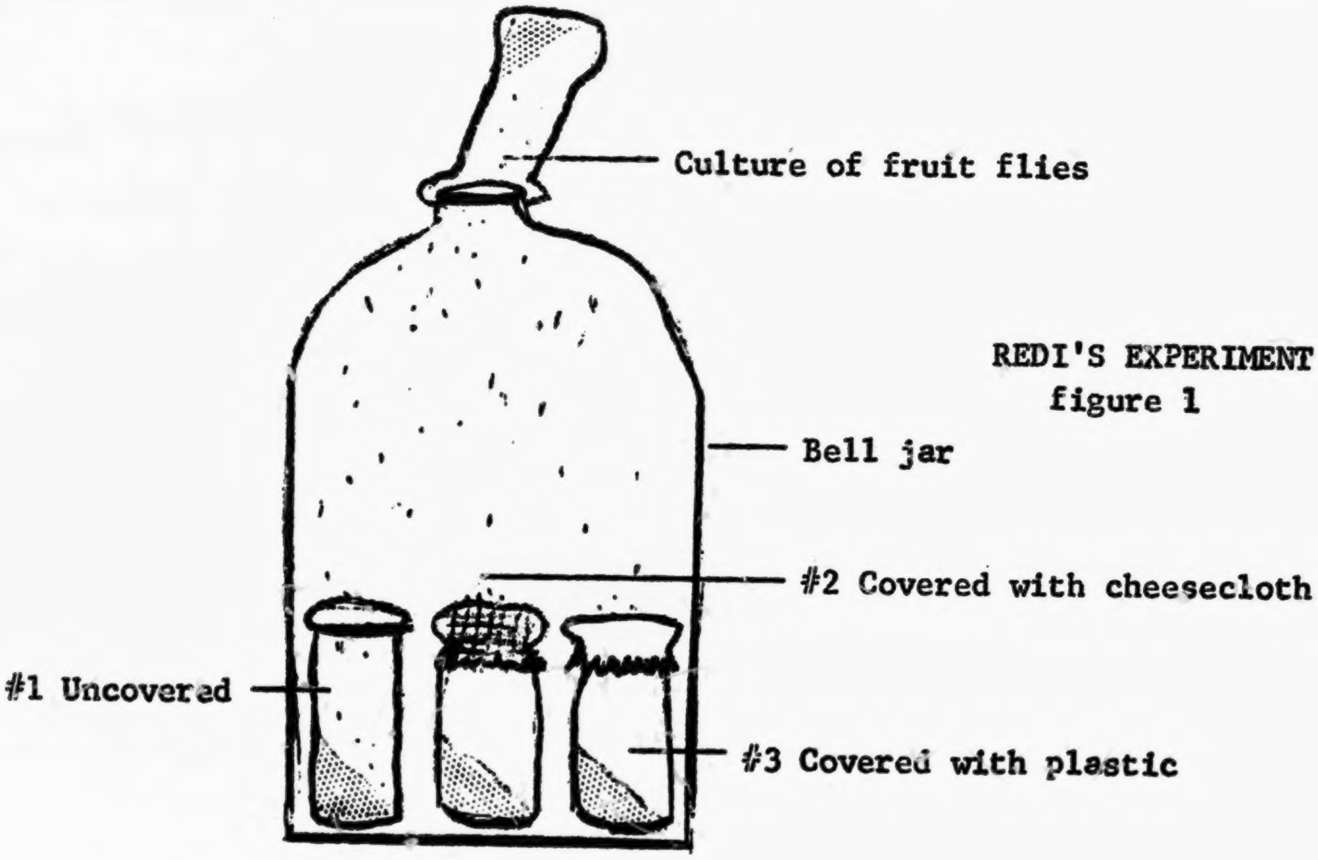
Flask #7 Place 70 ml of beef broth in a flask. Place a stopper in flask. Do not heat.

BE SURE THAT ALL FLASKS ARE LABELED CAREFULLY AND ACCURATELY. Place these flasks on the demonstration table (not in the direct sunlight or over the radiator)

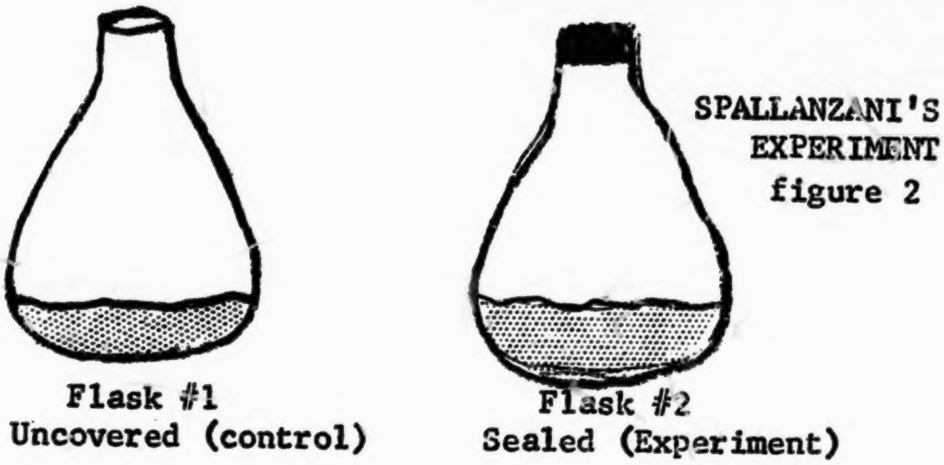
Students should make observations every day, finally from week to week. When changes in broth have occurred, note color, odor, etc. Keep a record of changes and the date when these changes appear.

QUESTIONS

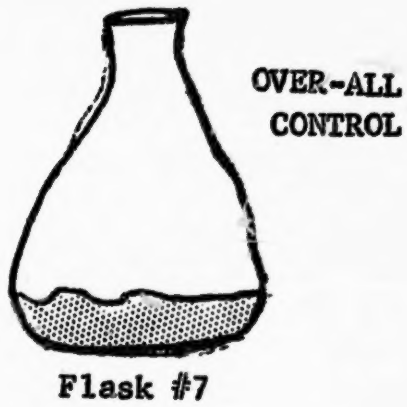
1. What is the purpose of the S-shaped tube in flask #6?
2. Why is it important to leave flask #3 uncovered?
3. What practical applications have been made from these experiments?


Culture of fruit flies
Bell jar
#2 Covered with cheesecloth
#1 Uncovered
#3 Covered with plastic

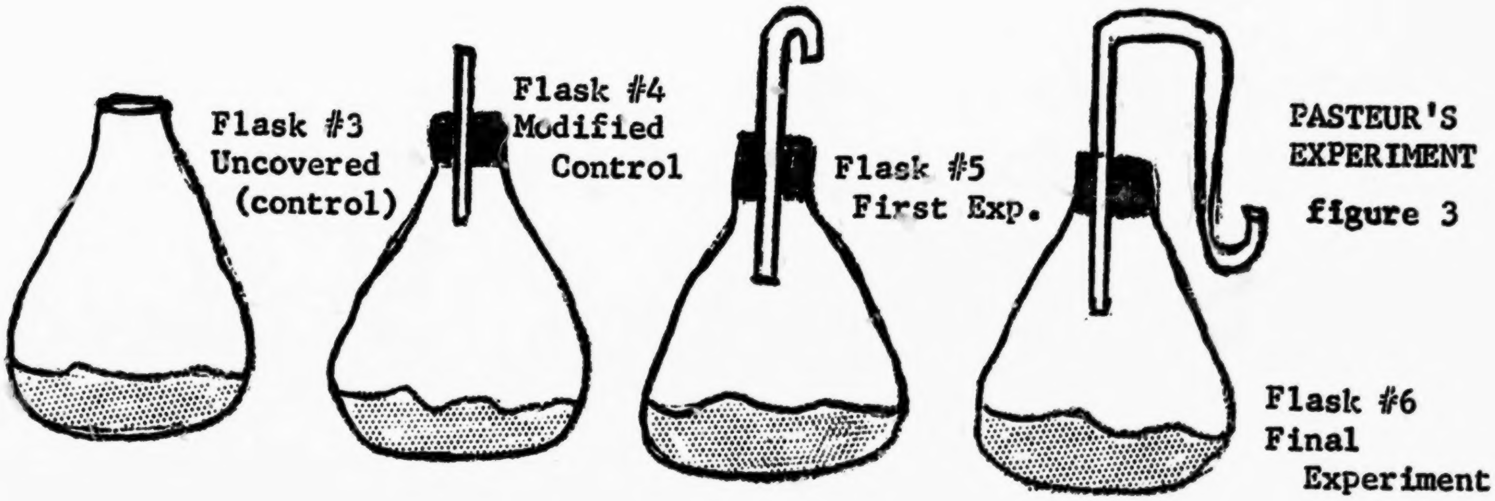
REDI'S EXPERIMENT
figure 1


Flask #1
Uncovered (control)
Flask #2
Sealed (Experiment)

SPALLANZANI'S
EXPERIMENT
figure 2

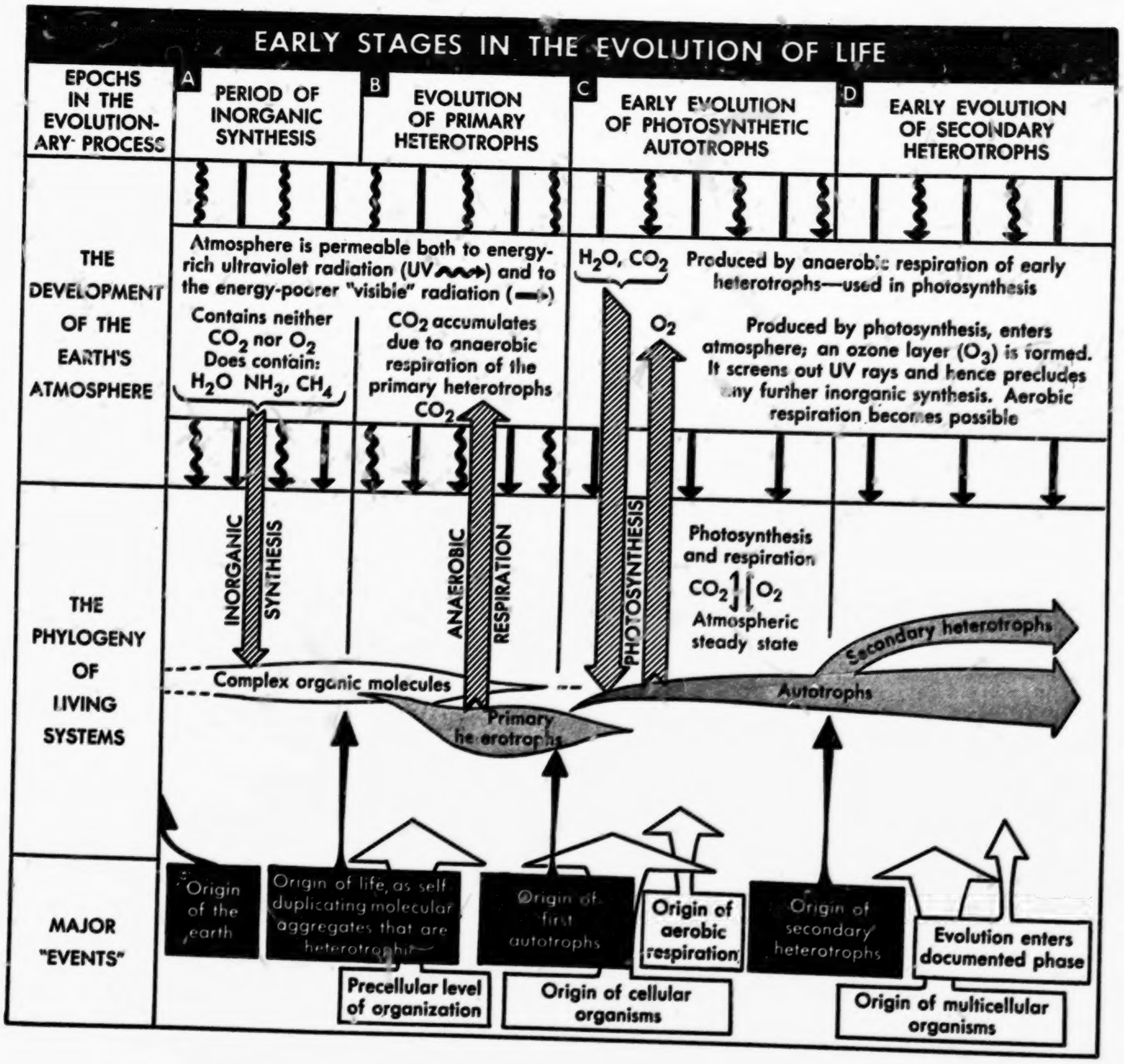


OVER-ALL
CONTROL


Flask #3
Uncovered
(control)
Flask #4
Modified
Control
Flask #5
First Exp.
Flask #6
Final
Experiment

PASTEUR'S
EXPERIMENT
figure 3

Excerpted from Simpson, Pittendrigh, and Tiffany. Life: An Introduction to Biology. New York: Harcourt, Brace and Company, 1957. p. 738. (Title III - Collection) (Reprinted with permission of publisher.)


EARLY STAGES IN THE EVOLUTION OF LIFE
EPOCHS IN THE EVOLUTIONARY PROCESS
A
PERIOD OF INORGANIC SYNTHESIS
B
EVOLUTION OF PRIMARY HETEROTROPHS
C
EARLY EVOLUTION OF PHOTOSYNTHETIC AUTOTROPHS
D
EARLY EVOLUTION OF SECONDARY HETEROTROPHS
THE DEVELOPMENT OF THE EARTH'S ATMOSPHERE
Atmosphere is permeable both to energy-rich ultraviolet radiation (UV) and to the energy-poorer "visible" radiation
Contains neither CO_2 nor O_2
Does contain: H_2O NH_3, CH_4
CO_2 accumulates due to anaerobic respiration of the primary heterotrophs
CO_2
H_2O, CO_2
Produced by anaerobic respiration of early heterotrophs—used in photosynthesis
O_2
Produced by photosynthesis, enters atmosphere; an ozone layer (O_3) is formed. It screens out UV rays and hence precludes any further inorganic synthesis. Aerobic respiration becomes possible
THE PHYLOGENY OF LIVING SYSTEMS
INORGANIC SYNTHESIS
ANAEROBIC RESPIRATION
PHOTOSYNTHESIS
Photosynthesis and respiration
CO_2 O_2
Atmospheric steady state
Complex organic molecules
Primary heterotrophs
Autotrophs
Secondary heterotrophs
MAJOR "EVENTS"
Origin of the earth
Origin of life, as self duplicating molecular aggregates that are heterotrophic
Precellular level of organization
Origin of first autotrophs
Origin of cellular organisms
Origin of aerobic respiration
Origin of secondary heterotrophs
Evolution enters documented phase
Origin of multicellular organisms

REVIEWING METRIC MEASUREMENT

PURPOSE (Review)

The following activity is provided to help the student review concepts about the metric system; to re-orient thinking in terms of centimeters instead of inches; and to learn basic measurement units and how they are used in the laboratory.

ACTIVITY MATERIALS

Meter sticks, rulers (marked in millimeters)
Ditto sheet with questions and directions

WHAT TO DO

Prepare a ditto sheet that will give the student the following information:

> The unit of length in the metric system is the meter, abbreviated as m. The meter is equivalent to 100 centimeters (cm) or 1,000 millimeters (mm) or 1 million microns (μ). One angstrom (Å) is equivalent to 0.001μ, therefore 10,000,000 Å are equivalent to 1 mm.

thousandth (milli) millimeter	hundreth (centi) centimeter	tenth (deci) decimeter	one meter

> 1,000 times (kilo)
> kilometer

> One meter is equivalent to 39.37 inches, while a micron is equivalent to 1/25,000 of an inch.

Using a meter stick, answer the following questions:

1. The meter stick is divided into how many centimeters?
2. The meter stick is divided into how many millimeters?
3. How many millimeters are equivalent to one centimeter?
4. With your meter stick measure the top of your desk as to length and width. Record this measurement in meters, in millimeters, and centimeters.
5. Measure the width and length of your textbook in meters, centimeters, and millimeters.
6. Measure a microscope slide in centimeters and millimeters.

RULES ON USING MICROSCOPE

PURPOSE

To learn the proper use of the microscope. Attaining skill in its use will be an invaluable tool in observations and experiments in semester's work in biology.

ACTIVITY MATERIALS

Glass slide and cover slip
Lens paper
Newsprint and magazine half-tone pictures
Transparent millimeter ruler
Small beakers and eyedroppers
Forceps
Biology study chart Microscope (Standard supply list stock No. 813261)
Wall chart of the microscope
Microscope

WHAT TO DO

Review the parts of the microscope by using the wall chart of the microscope. Students use biology study chart Microscope to aid in learning the names of the parts of the microscope and their functions.

Students practice use and care of the microscope by following the directions given below:

1. Always carry the microscope upright by holding the instrument with one hand on the arm of the microscope and one hand under the base.
2. Place the microscope on the desk gently with the arm facing student (unless otherwise directed) (Don't let it hit against anything--it may jar parts out of line)
3. Never allow the direct rays of the sunlight to fall on any part of the microscope (especially the mirror)
4. Clean lenses with lens paper (Never use cloth or tissue). For spots that cannot be removed easily, the teacher may use xylol.
5. Be sure that the coarse adjustment is turned all the way down.
6. Check the diaphragm to be sure it is open.

---

7. Place the low power objective over the opening on the stage

8. While looking through the eyepiece, adjust the mirror for the best possible light (blue-white). Use the plane mirror (flat surface) for low power work and the concave mirror (dipped-in center) for high power work. (Use diaphragm until brightness suits you)

9. Place the slide over the opening on the stage so that it is directly under the low power objective lens.

10. To focus: While looking through the eyepiece, turn the coarse adjustment (large knob) toward you slowly until the object comes into view. (If the object does not appear, move the slide so that the object will be more directly under the lens).

11. When the object is focused, use the fine adjustment to get a sharp focus (small knob).

12. When object is in focus under low power, turn the revolving nosepiece until the high power objective lens clicks into place. The object should be in focus. FROM NOW ON USE THE FINE ADJUSTMENT ONLY.

13. When the microscope is ready to be returned to its storage area, remove the slide and place the low power objective over the opening on the stage. Leave the diaphragm open and turn the coarse adjustment all the way down.

14. Wash the slide and cover slip and dry each carefully. Return to slide box.

15. It is good practice to keep both eyes open when looking through the eyepiece. You will soon learn to disregard the image from the "off" eye (with concentration) and so will avoid the strain of holding this eye closed.

    For information on explanation of magnification and resolving power (See American Optical Company, Instrument Division, The Microscope.)

ORIGIN OF LIFE
THEORIES

UNIT ONE: FOUNDATIONS OF LIFE

RULES ON USING MICROSCOPE

Place a small piece of newsprint containing the letter "e" (lower case) on a glass slide so that the letter is upright (as when you read the letter). Add a drop or two of water with a pipette (medicine dropper) and place the cover slip on as in figure 1. (try to avoid getting air bubbles in the process). Press the cover slip gently to force out air bubbles that may form. Observe the letter through the low-power objective lens of the microscope. Draw the letter "e" as it looks through the microscope. Move the letter to the right, left, up, down, while looking through the eyepiece. Which way does the letter move for each direction given? (See figure 2.) Write observations on your data sheet which also contains the drawing of the letter "e". When the letter is in perfect focus under low-power, use the high-power objective lens to get a greater magnification. Make a drawing of what you see under high power. Is the entire letter "e" visible? If not, why not?

Remove the newsprint slide, save it for use later. Place a plastic ruler (transparent) on the stage of the microscope across the middle of the field of vision. Be sure that the low-power objective is over the opening on the stage. Focus and determine the diameter of the low-power field in millimeters and in microns. A micron is one-thousanth of a millimeter. Now place the slide with the letter "e" on the stage of the microscope, observing it under low-power determine the size of the letter with the transparent plastic rule (in microns) or to the best of your ability compare the size of the letter with the size of the field. How high is the letter in actual millimeters? In microns?

Mount a piece of paper taken from a magazine half-tone picture in a drop of water on a slide and observe under the low-power of the microscope. Be sure you've placed a cover slip on the object. How many "dots" can you see across the low-power field? How far apart are the "dots" on the paper you've mounted? Give answer in microns) Compare size of field of vision and try for an approximate answer.

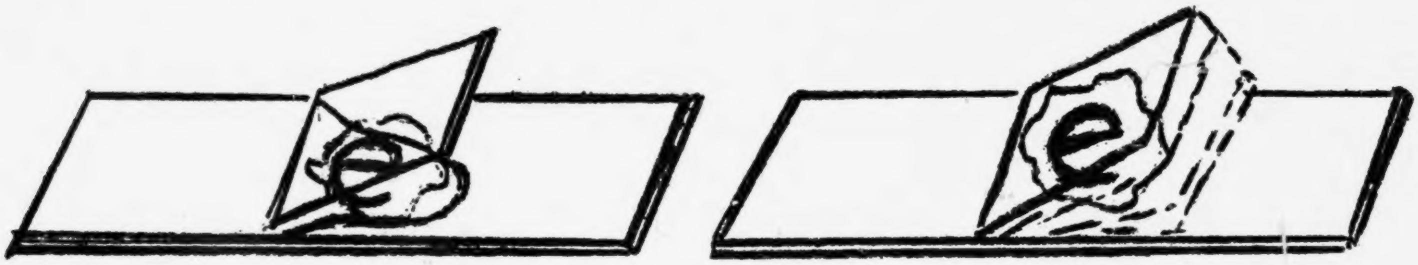
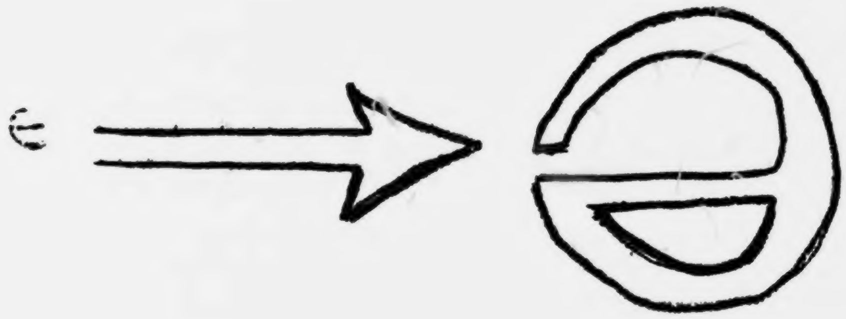
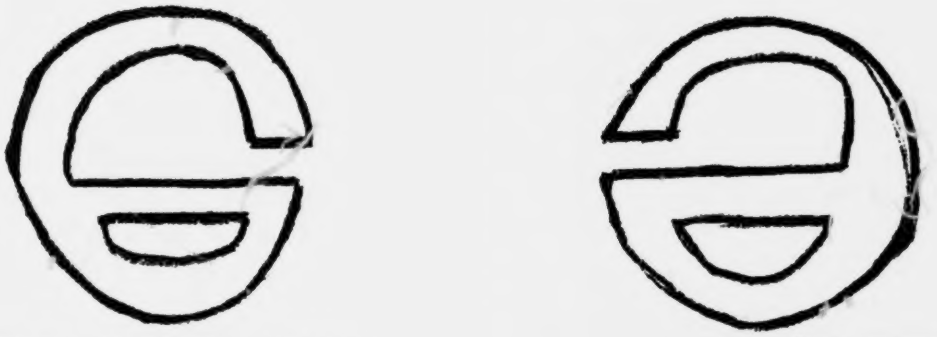


figure 1

RULES ON USING MICROSCOPE

Why do the two observations differ? (naked eye and microscopic?) In what ways do they differ?





Note that the image is not only inverted (upside down)

But also reversed right to left

figure 2

PREPARATION AND OBSERVATION OF SLIDES

PURPOSE

To gain and improve skill in preparation and observation of living plant and animal materials for use in microscopic work (Proper techniques in staining and mounting of plant and animal materials).

ACTIVITY MATERIALS

Stains--methylene blue, iodine potassium-iodine solution
Microscope
Microscope slides and cover slips
Pipettes (medicine droppers)
Dropping bottles or small beakers
Onion
Green algae
Culture of yeast
Culture of protozoa
Soft paper towels cut into sections

WHAT TO DO

STUDY OF PLANT CELLS

Strip a small piece of the skin on the inside of one of the layers of an onion. Place section on a glass slide in a drop of water. Add potassium iodide solution to help stain the cell parts. Place cover slip over this (as in figure 1, p. 63). Observe under low-power. Move the slide around until you have a clear image of a group of cells. Place this group of cells in the center of the field of vision and focus. Draw 3 or 4 cells in the group to show their shape and arrangement.

Examine a drop of yeast culture on a clean slide. Add a cover slip and observe under low-power and then under high-power. Describe the yeast cell. What structures can you identify in the yeast cell? Now add iodine-potassium-diodide solution to the yeast drop. Observe under low and high power. Make sketches of several yeast cells.

Place several strands of filamentous green algae on a slide in a drop of water. Place cover slip on this and observe under low-power. Observe under high-power. Make a sketch of several cells in filament under low-power. Make a sketch of one cell in filament under high-power.

Place a pinch of Diatomaceous Earth in a drop of water. Observe under low-power and high-power.

STUDY OF CELLS FROM HUMAN BODY (OR OTHER ANIMAL BODIES)

Scrape the inside of the cheek with a blunt toothpick (see Safety directions, p. 49, Part 1)Then rub the edge of the toothpick in a drop of water on a clean glass slide. Add a drop of iodine-potassium-iodide solution and cover slip. Observe under low-power. Observe under high-power. Make a sketch of the epithelial cheek cells under low-power.

Place an eyebrow hair on a slide in a drop of water. Place a cover slip over this and observe under low-power. Make a drawing of observations. Examine the entire length of the eyebrow hair from tip to root.

STUDY OF ONE CELLED ANIMALS

Place a drop of pond water culture on a clean glass slide. Add a cover slip to this very gently. Observe one celled animals under low power. Locate one of the larger organisms and try to follow its movement through the water. This requires some skill. In what direction must you move the slide, as compared to the direction in which the animal moves? In order to follow the movements of these organisms, it is necessary to use both hands . . . one on the slide and one on the fine adjustment. As the animals move about they not only change their position in the field, but they also move in and out of the sharp focus. Can you guess at the depth of water on slide? Why are these animals able to move in and out of sharp focus?

To slow down the motion of microscopic animals so they can be seen to better advantage, add a few fibers of absorbent cotton to the drop of water and then add protozoan culture. Sometimes the use of methyl cellulose (a thick viscous type solution) and a drop of culture together on the slide will slow down the movement of these microorganisms.

Use a 0.1 per cent water solution of methylene blue to stain the vital parts of paramecia. It will slow them down but not kill them immediately.

Shred a piece of lens paper. Tease some of the fibers loose on a slide and then place culture drop on this.

OTHER SLIDE PREPARATIONS IN LIEU OF ABOVE*

Take a short length of rhubarb stem--the freezer is a good source as the garden--and cut it with a sharp knife into eighth-inch lengths. Place these in a test tube, beaker, or saucepan, according to the scale of your operation with just enough water to cover them. Bring to the boil and boil for a minute or two until they are softened. Add as much glycerin as you have water and mix well without shaking. This material can be prepared in advance in any quantity required and it will keep indefinitely.

Now lay a clean coverslip on a clean flat surface-- a piece of 5" x 3" index card is excellent--and lay on the coverslip a couple of strands of fairly thin nylon. Now take a small drop of rhubarb sludge with an eyedropper and place it on the center of the coverslip. Take a clean slide and lower it horizontally until the slide touches the drop. Press down lightly until the slide touches the supports, then pick the slide up and turn it over before putting it on the stage of the microscope. If too big a drop is used, the coverslip will slide off when the slide is inverted. If too small a drop is used, there will be a lot of air spaces round the edge.

Collect in the garden in summer, or from a friendly forist in winter, some petals of "touch-me-not" (Impatiens balsamina) or "jewel weed" (Impatiens bicolor). Cut them in 1/8" squares and put them in alcohol. As soon as they have lost their color, pour off the alcohol and replace it with 50% glycerin. Now place a small drop of 50% glycerin in the center of a coverslip, lay a hair or fine nylon thread along each side, and then place one of the small squares of petal in the drop. This is an excellent introduction to the use of forceps. Lower the slide on top, invert and examine. The vein structure will be well shown but the real surprise will be the numerous jagged crystals.

Place a pinch of cornstarch in a test tube, add enough alcohol to cover it, and then sufficient water to form an opalescent fluid. Prepare a slide in the manner described above and then examine the starch grains. This will help to accentuate the use of the high power objective.

Rhoeo discolor is a common succulent house plant with a green upper surface and purple lower surface to its leaf. The purple lower epidermis can readily be stripped off and mounted in water sealed with petroleum jelly. (see p.   ) Under the microscope the guard cells of the stomata are seen to be bright green while the surrounding epidermal cells are brilliant purple.

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*Microtechnique--temporary whole mounts. Ward's Curriculum Aid #4.

UNIT ONE: FOUNDATIONS OF LIFE

MICROSCOPIC MAGNIFICATIONS

PURPOSE

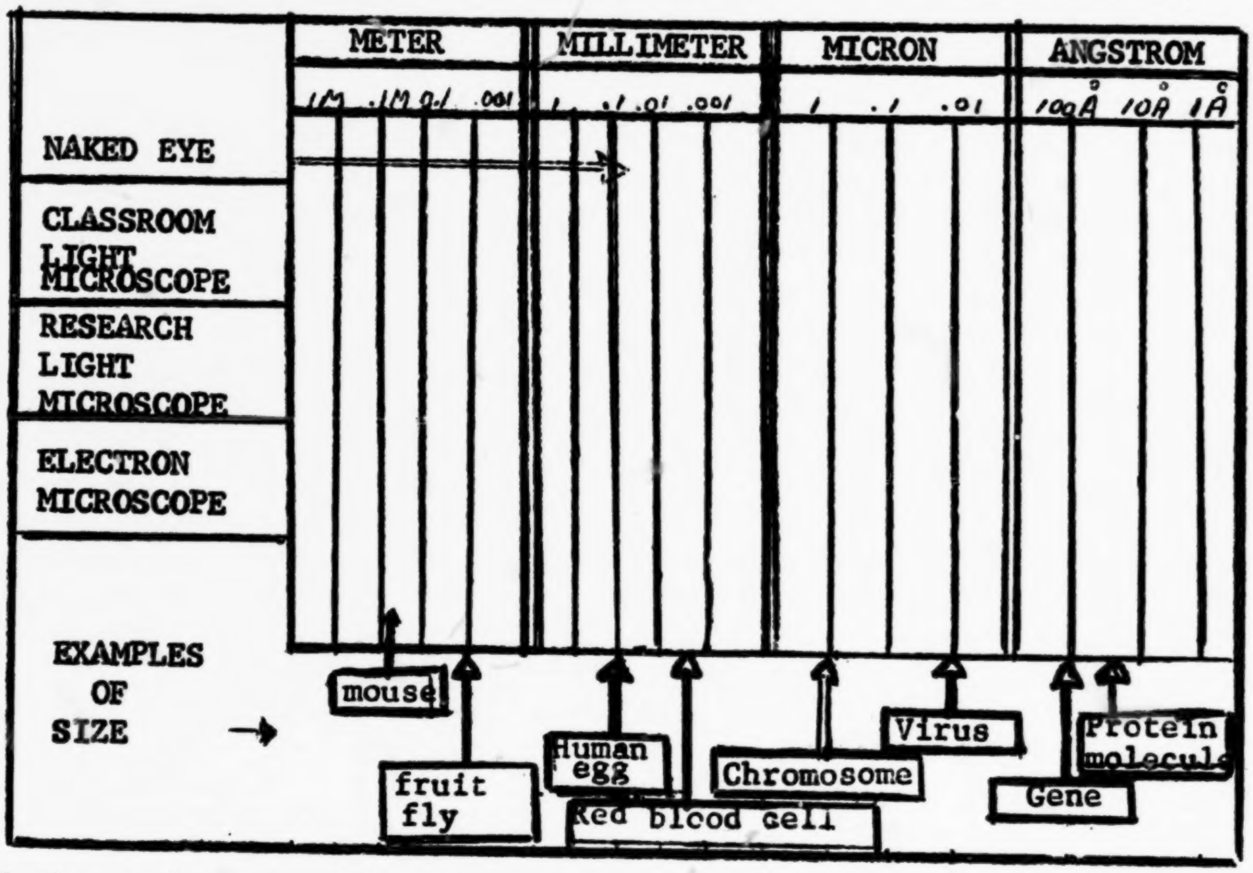
To strengthen and support information gained about the use of the microscope.
To stimulate the student in using references concerning special types of microscopes microscopes and their uses in the biology laboratory.

ACTIVITY MATERIALS

A list of reference materials for homework assignment
Ditto sheet of information below
Summary sheet of various types of microscopes (provided by teacher or included in assignment for student)

WHAT TO DO

Student does research work to help fill in the ditto chart given below.* A short summary of the various types of microscopes would add immeasurably to this activity.


METER
MILLIMETER
MICRON
ANGSTROM
1M .1M 0.1 .001
1 .1 .01 .001
1 .1 .01
100Å 10Å 1Å
NAKED EYE
CLASSROOM LIGHT MICROSCOPE
RESEARCH LIGHT MICROSCOPE
ELECTRON MICROSCOPE
EXAMPLES OF SIZE →
mouse
fruit fly
Human egg
Red blood cell
Chromosome
Virus
Gene
Protein molecule

"HOW SMALL IS SMALL" **

Find the maximum magnification of each microscope listed and draw an arrow from the microscope to some portion of the chart that will indicate its max. mag.

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*Reference: Simpson, Gaylord, et al. Life: An Introduction to Biology. New York: Harcourt, Brace and Co., 1957. p. 45.

**Drawn after BSCS Yellow Version p. 5, Teacher's Guide. (Reprinted with permission of publisher.)

CONCEPTS TO CONSIDER

Viruses are particles, smaller than most cells, composed of protein and nucleic acid

Viruses are unable to grow and carry out any of the processes characteristic of living things outside of a living cell

Reproduction of a virus takes place within the living cell. Outside the cell a virus is inert

Bacteriophages are viruses that infect bacterial cells

Rickettsial bodies are parasitic particles, a little larger than viruses and smaller than bacteria, which carry out the processes characteristic of living things in the living cell; outside of the living cell it is inert

Rickettsial bodies are not especially specific as to host

Viruses are very specific as to host

Bacteria are basically single-celled organisms but in some cases may be aggregated together into colonies and or other multicellular masses

All bacteria reproduce by fission

Bacteria lack a definite nucleus and instead have granules of nucleoproteins dispersed in the protoplasm

Bacteria are generally classified into three forms, spiral, rod, and sphere

Some bacteria have fine surface flagella which enable a certain amount of mobility

Bacteria usually possess a cell wall made of a chitinlike material or complex polysacchrides

Bacteria may be saprophytic or parasitic as a general rule. A few bacteria carry on photosynthesis using a pigment called bacteriochlorophyll. Some bacteria carry on chemosynthesis

The most important bacteria are those found in the soil and ocean which cause decay and play an important part in the releasing of free nitrogen gas, and those bacteria which cause disease of plants and animals

Blue-green algae do not possess chloroplasts but have granules of chlorophyll dispersed throughout its cytoplasm

Blue-green algae do not possess a true cell nucleus, the gene-containing nucleoproteins are clumped together more or less in the center of the cell with no bounding membrane

Blue-green algae are basically unicellular organisms but in some cases the cells may be aggregated together into colonies and other multicellular masses

Slime molds show plant-like and animal-like phases in their life cycle

Unicellular organisms very often classified according to their motility, such as cliates (cilia), Ameba and kin (pseudopods), etc.

Protozoa have definite nuclei and chromosomes. When they divide they go through the process of mitosis

Some protozoans are found in forms which live as parasites in bodies of man and animals, and which cause disease

Protozoa are animal-like protists

TEACHING APPROACH (Methods and Activities)

Discuss Virus, Rickettsial bodies and bacteria

- Display three-dimensional models of different types of viruses
- Pass out pictures of photomicrographs of viruses taken under an electron microscope (mount these pictures on tagboard so that they will not be torn easily)
- Impress students with size of some viruses by following: a millimicron equals 1,000 microns; 1,000,000 millimicrons equals 1 mm; 1,000,000,000 millimicrons equals 1 meter. Typical dimensions in the world of the virus in terms of millimicrons may be:

  9,000 millimicrons = small animal cell
  600 millimicrons = wavelength of yellow light
  60 millimicrons = average virus
  4 millimicrons = average viral protein subunit
  0.1 millimicrons = distance between atoms in a protein molecule

- Demonstrate "shadowing" by using a three-dimensional model of a cardboard polyhedron (method used to determine the shape of viruses by X-ray crystallography) Shine two lamps 60 degrees apart on a cardboard model of a polyhedron. See reference Wendell, Stanley, and Evans Valens. Viruses and the Nature of Life, p. 61.
- Demonstrate the parts of a virus by flannel board demonstration. See p. 76.
- Demonstrate the reproduction of a virus by flannel board demonstration. See p. 76.
- Students make a list of diseases caused by viruses
- Grow the tobacco mosaic virus in the classroom laboratory. See p.75.
- Discuss Rickettsial bodies
- Prepare a chart on the board that will compare viruses, Rickettsial bodies and bacteria, i.e., size in millimicrons, general shape, reproduction, how its grown in the laboratory, diseases it may cause, etc.
- Discuss the major types of bacteria as to their feeding habits, oxygen consumption, distribution, relationship to nitrogen cycle and to diseases
- See depth probes for classroom laboratory activities concerning bacteria

Discuss blue-green algae, slime molds, and protozoa

- Students bring in jars of pond water for class observation of blue-green alga
- Prepare and grow slime molds for classroom observation
- Using a flannel board demonstration discuss the plant-like and animal-like phases of the slime mold life cycle
- Demonstrate animal-like protists by flannel board cutouts or three-dimensional models and their means of motility or by a chalk-talk
- Discuss the major forms of protozoa
- Observe various protozoa under microscope
- See depth probes for activities in the classroom laboratory concerning protozoa

UNIT ONE: FOUNDATIONS OF LIFE

DEPTH PROBE

- GROWING TOBACCO MOSAIC VIRUS, p. 75 (Average Student Basic Activity - Optional). To demonstrate the inoculation of tobacco mosaic virus from cigarette tobacco. Students work in teams.

- VIRUS, p. 76 (Average Student Basic Activity). To illustrate the structure of a virus through the aid of flannel board. Teacher demonstration.

- CULTURE AND GROWTH OF MICROORGANISMS, pp. 77-79. (Average Student Basic Activity). To acquaint the student with techniques in culturing, growing, and identifying microorganisms. Students work in teams and pairs.

- STUDYING GROWTH PATTERNS OF MICROORGANISMS, pp. 80-84. (Average Student Basic Activity). To study the growth patterns of microorganisms by their form, surface, and margin, and the effects of light on these patterns. Students work in teams and pairs.

- CULTURE AND GROWTH OF SLIME MOLDS, pp. 85-86. (Average Student Basic Activity - Optional) or (More able - Basic Activity). To study the growth and structure of slime molds. Students work in groups or teacher demonstration.

- STRUCTURE AND FUNCTION OF PARAMECIUM, pp. 87-88. (Average Student Basic Activity). Detailed study of structure and function of a protozoan. Students work in pairs.

- A NON-LIVING ANALOGUE TO DEMONSTRATE INGESTION, DIGESTION, AND EXCRETION, pp. 89-90. (Average Student Basic Activity - Optional). To understand something about the mechanisms whereby an organism ingests some objects and excretes others. Student teacher demonstration.

"TOOLS" FOR EXTENDING CONCEPTS

- Plan to show films:

  "Protozoa," Fsd 593.1-2
  "Simple Plants, Bacteria"
  "Life In A Drop Of Water," Fsd 576-1
  "Microscopic Life," Fsd 576-6
  "Bacteria, Laboratory Study," Fsd 576-8

- Plan a bulletin board entitled "LIVING OR NON-LIVING," and show the life cycle of a virus.

- Assign students reports on Robert Koch, Louis Pasteur, Lister, Iwanowski, and others
- Encourage a student team to prepare various three-dimensional models of viruses for display around the classroom
- Encourage some students to prepare mobiles of various protozoans to hang around the room
- Encourage students to read the book, Viruses and the Nature of Life by Wendell Stanley and Evans Valens. New York: Dutton, 1961.
- Encourage students to make their own preparations of pond cultures for study during and after class. Students may prepare a variety of drawings or cut-outs to describe their observations.
- Encourage some students to carry on laboratory experiences using Tobacco Mosaic Virus on tobacco plants at home.
- Plan a bulletin board entitled "LIFE IN A DROP OF WATER" depicting various protists seen microscopically by the class.
- Stimulate a group of students to grow and care for a slime mold culture.
- Have a student report on microbiological techniques used in your class or to be used in your class, such as how to use the pipette, inoculating a petri dish, sterilizing, and others.

PLANNING AHEAD

- Assign students the task of bringing to class raw carrots, potatoes, and raw eggs.
- Collect ringstands, burette clamps, glass tubing, karo syrup for osmosis experiment.
- Order sausage casing from science center or local butcher.
- Check protozoan culture for Paramecia.
- Reserve supplies of Elodea and store in aquarium.
- Collect supplies for food testing experiment such as Benedict's Solution, Iodine Solution, Biuret's Reagent, and assign students to bring in various foods for testing day
- Collect red, blue, green, yellow, purple cellophane paper.
- Locate prism and good source of a light beam.
- Read materials about paper chromatography as a background for experiment.
- Check supplies of acetone, petroleum ether, test tubes, and Whatman paper #1 (if available).
- Interest some more able students to help put together a volumeter. See p.
- Locate several potted geranium plants.
- Prepare starch and plain agar petri plates, reserve a package of corn grains.
- Prepare an ample supply of FAA solution (See p.)

- Reserve several bottle corks.
- Assign students to bring in single edge razors to supplement supply.
- Prepare a large poster showing an enlarged chromatogram with bands of various colors and labels to show separation of chlorophyll extract.
- Prepare a bulletin board showing light--its radiations visible and non-visible, wave lengths, and others.

BROADENING "CONTENT HORIZONS"

Teacher References:

- Burnet, Sir Macfarlane. "Viruses," Scientific American, (May, 1951)
- Frankel-Conrat, Heinz. "Rebuilding a Virus," Scientific American, (June, 1956)
- Luria, Salvador. "The T_2 Mystery," Scientific American, (April, 1955)
- Pollard, Ernest. "The Physics of Viruses," Scientific American, (Dec., 1954)
- Knight, C. A., and Dean Fraser. "The Mutation of Viruses," Scientific American, (July, 1955)
- Stent, Gunther. "Multiplication of Bacterial Viruses," Scientific American, (May, 1953)
- Jacob, Francois, and Elie Wollman. "Viruses and Genes," Scientific American, (June, 1961)
- Zinder, Norton. "Transduction in Bacteria," Scientific American, (Nov., 1958)
- Burnet, F., and W. Stanley. The Virus, Three Volumes. New York: Academic, 1929.
- "Suggestions for Experiments in Bacteriology," The American Biology Teacher, (June, 1960) Volume 22, No. 6
- Pelczer, J. M., and R. D. Reid. Microbiology. New York: McGraw-Hill, 1958.

Student References:

- Articles suggested on page 73 from Scientific American.
- Stanley, Wendell, and E. Valens. Viruses and the Nature of Life. New York: Dutton, 1961.
- Williams, Greer. Virus Hunters. New York: Knopf, 1959.
- Weidel, Wolfhard. Virus. New York: Noble and Noble, 1959.
- De Kruif, P. Microbe Hunters. New York: Pocket Books, 1926.
- Drew, J. Man, Microbe, and Malady. Baltimore: Pelican Books, 1940.
- Burnet, F. Virus and Man. Baltimore: Pelican Books, 1957.

Textbook References:

- Moon, Otto, and Towle. Modern Biology. pp. 91-125, 229-239, 558-579
- Smith, Ella. Exploring Biology, 5th Edition. pp. 74-87, 107-121, 428-461

GROWING TOBACCO MOSAIC VIRUS

PURPOSE

To demonstrate the inoculation of tobacco mosaic virus from cigarette tobacco in living tobacco plants.

ACTIVITY MATERIALS

Half a cigarette (any brand)
Mortar and pestle
Ten ml of 0.1 M K_2 HPO
(see appendix p.   ).

*One Turkish tobacco plant (potted)
*One Xanthi tobacco plant (potted)
*One tomato plant (in season)

WHAT TO DO

Dump the tobacco from half a cigarette into a mortar and grind the tobacco fine while it is dry.

Add 10 ml of 0.1 M K_2HPO_4 and continue to grind thoroughly.

Dip forefinger into the juicy mix and gently stroke the surface of the leaves of the test plants, wetting the finger repeatedly. (Use cotton swab instead of forefinger). Be sure there is a definite point of injury on the leaf to receive virus from mixture.

Wash hands to remove contaminating virus. Water the leaves of the test plants to wash off excess material. Observe plants at regular intervals for symptoms. Local lesions (brown spots) should appear on the Xanthi plants after two to three days. Vein clearing will appear in the Turkish tobacco plant in five to eight days, and mottling of the leaves will be evident in eight to twelve days. Mottling of the leaves will appear in the tomato plant also in eight to twelve days.

Adapted from "Molecular Biology for High School Teachers", University of California, 1961. C. A. Knight. Viruses and Life.

*Secure from Science Center on fresh materials order.

VIRUS

PURPOSE

To illustrate the structure of a virus and to understand the concept of viral reproduction . . . through the aid of the flannel board.

ACTIVITY MATERIALS

Stanley, Wendell, and E. Valens. Viruses and the Nature of Life. New York: Dutton, 1961.

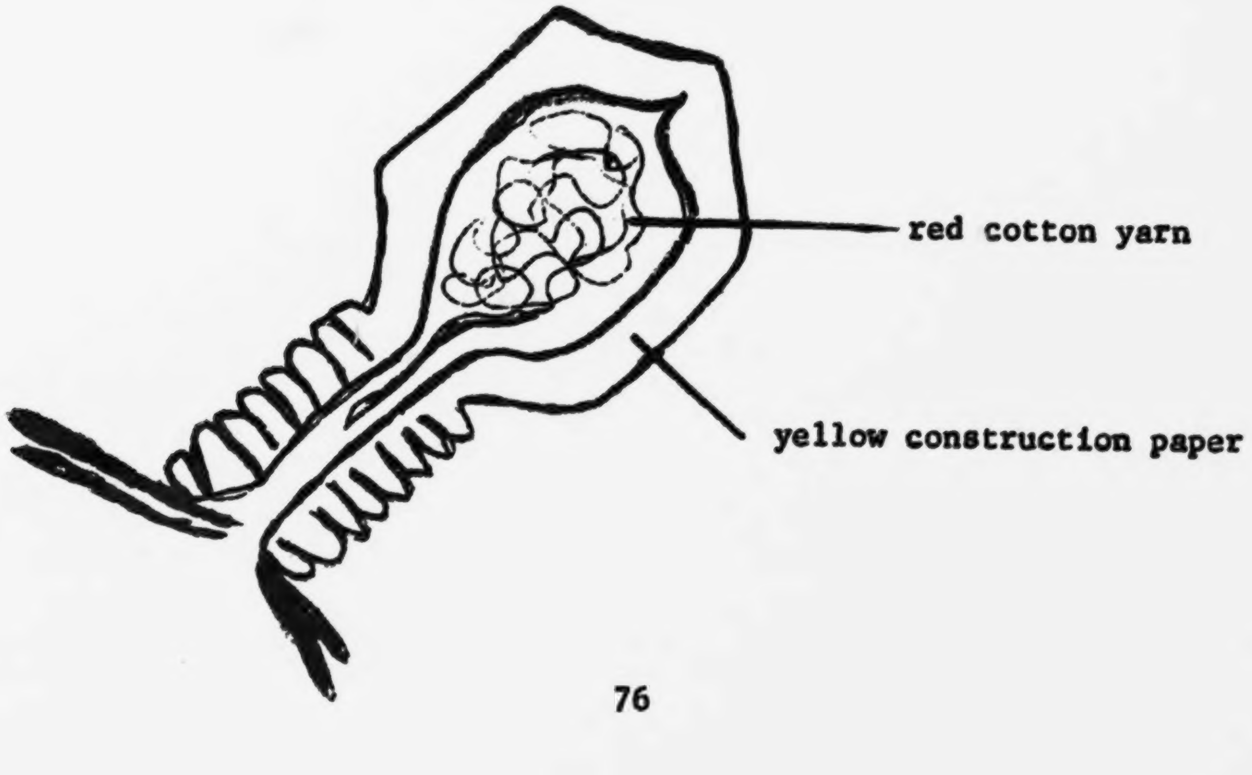
Articles from Scientific American Magazine, see page 73.

Construction paper of various colors
Flocking paper for backing of cutouts
Scissors
Flannel board
Cotton yarn or other thread like material

WHAT TO DO

Prepare cutouts of a typical virus with labels of the various parts on separate pieces of paper. Place the parts of the virus on the flannel board and use the labels in their appropriate places on the flannel board. Prepare cutouts of cells to demonstrate the principle of invasion of living cells by a viral particle.

See design for cutout below:



CULTURE AND GROWTH OF MICROORGANISMS

PURPOSE

To acquaint the student with techniques in culture and growth of microorganisms and to learn some methods for identification through growth patterns, microscopic examination and macroscopic appearence.

ACTIVITY MATERIALS

Stacking bowls (finger bowls)
Microscope
Slides and cover slip
Teasing needles
Forceps
Filter paper
Wax marking pencils
Pipettes
Cottage cheese
Squash or pumpkin
Grains of peppercorn
Hay
Dried beans
Lettuce leaves
Moldy bread
Grapes
Rotting fruits: tomato, apple, orange, lemon
Pond water with decaying materials
Rich soil
Corn starch

WHAT TO DO

Mark stacking bowls with wax pencil from 1 through 10 and to each bowl add the following:

(1) Crushed grapes with enough water to cover them
(2) Rotting fruit
(3) Pond water containing bottom and surface decaying materials
(4) A few dried beans and 400 ml of water
(5) Hay to cover bottom of stacking bowl and 400 ml of water
(6) Several lettuce leaves in a small amount of water
(7) Piece of moldy bread and squash (or pumpkin) with dust on it and water to moisten the material before exposing it to air for 24 hours
(8) Cottage cheese spread over bottom of bowl
(9) 20 grains of peppercorn and 250 ml of tap water
(10) Place a piece of filter paper on bottom of finger bowl. Add 5% starch to rich soil to cover the bottom of the bowl (1 inch in depth). Add water and mix to a fine consistency.

Place bowls in a stack except for bowl (2). Do not place them in direct sunlight. Be sure there is a very small space between each stacking bowl (not too tight of a fit).

Place bowl (2) a few yards away from the rest of the stacking group (cover with a glass plate)

Examine each bowl daily. Which of these can be recognized without the use of the microscope? What are the visible growth forms of these?

Take bits of the visible growths and mount them in water on a slide for microscopic examination. Do organisms from macroscopically different growth forms also look different under the microscope?

Take a few drops of water from the different bowls and observe under the microscope. Which microbial types do you find?

Retain all cultures for later study.

Adapted from Laboratory Manual, BSCS Green Version, Experiment 5.1

UNIT ONE: FOUNDATIONS OF LIFE

Make observations over a three day period and place data in chart given below:

	Days	Odor	Growths--Shapes & Color	Name of Microbial Types
Bowl 1	1 2 3			
Bowl 2	1 2 3			
Bowl 3	1 2 3			
Bowl 4	1 2 3			
Bowl 5	1 2 3			
Bowl 6	1 2 3			
Bowl 7	1 2 3			
Bowl 8	1 2 3			
Bowl 9	1 2 3			
Bowl 10	1 2 3			

STUDYING GROWTH PATTERNS OF MICROORGANISMS

PURPOSE

To study the growth patterns of microorganisms on a solid culture medium; to study form, color, surface, and margin of these colonies; to study the effects of light on these colonies.

ACTIVITY MATERIALS

Source of microorganisms
Inoculating needles
Sabouraud glucose agar medium
Petri dishes
Masking tape or wax marking pencils
Plastic disk for measuring (See directions for obtaining this disk) p.

WHAT TO DO

Divide the class into four teams. Each team should consist of six students, but no more than eight students. Prepare sterile agar plates with Sabouraud glucose agar medium. Each team will have six petri dishes, inoculating needles, and other equipment needed.

Prepare each of the six petri dishes in the following manner. Cut a small strip of masking tape (freezer tape) and place on the bottom half of the petri dish. Each member of teams I and II will mark their dishes starting from (1) to (5). Each dish will also have the date of inoculation on the tape and the team number.

Prepare six petri dishes as mentioned above by teams III and IV but numbering dishes (6) through (10).

Teams I and II will inoculate petri dish (1) with inoculant from stacking bowl (1) of exercise on p. 77; petri dish (2) from bowl (2) and so on. Petri dish (6) may be inoculated from any of the five bowls (1-5) but the student should make sure to use some growth not previously used in other petri dishes.

Teams III and IV will inoculate petri dish (6) with stacking bowl (6) and petri dish (7) from bowl (7) and so on. Petri dish (11) may be inoculated from any of the five bowls (6-10), but the student should make sure to use some growth not previously used in other petri dishes.

After inoculation has been made, each petri dish should be scotch taped and placed in the following manner:

Team I	Place all six petri dishes in a dark drawer at room temperature
Team II	Place all six petri dishes in some part of the classroom but away from direct sunlight
Team III	Place all six petri dishes in a candle jar
Team IV	Place all six dishes in some part of the classroom but away from direct sunlight

Allow all petri dishes so inoculated to incubate for several days using the plastic disk to measure the growth each day and recording the data on the following sheet.

NOTE TO THE TEACHER

Start the inoculation of plates at the beginning of the week so that at least four days of observation may be noted by student teams.

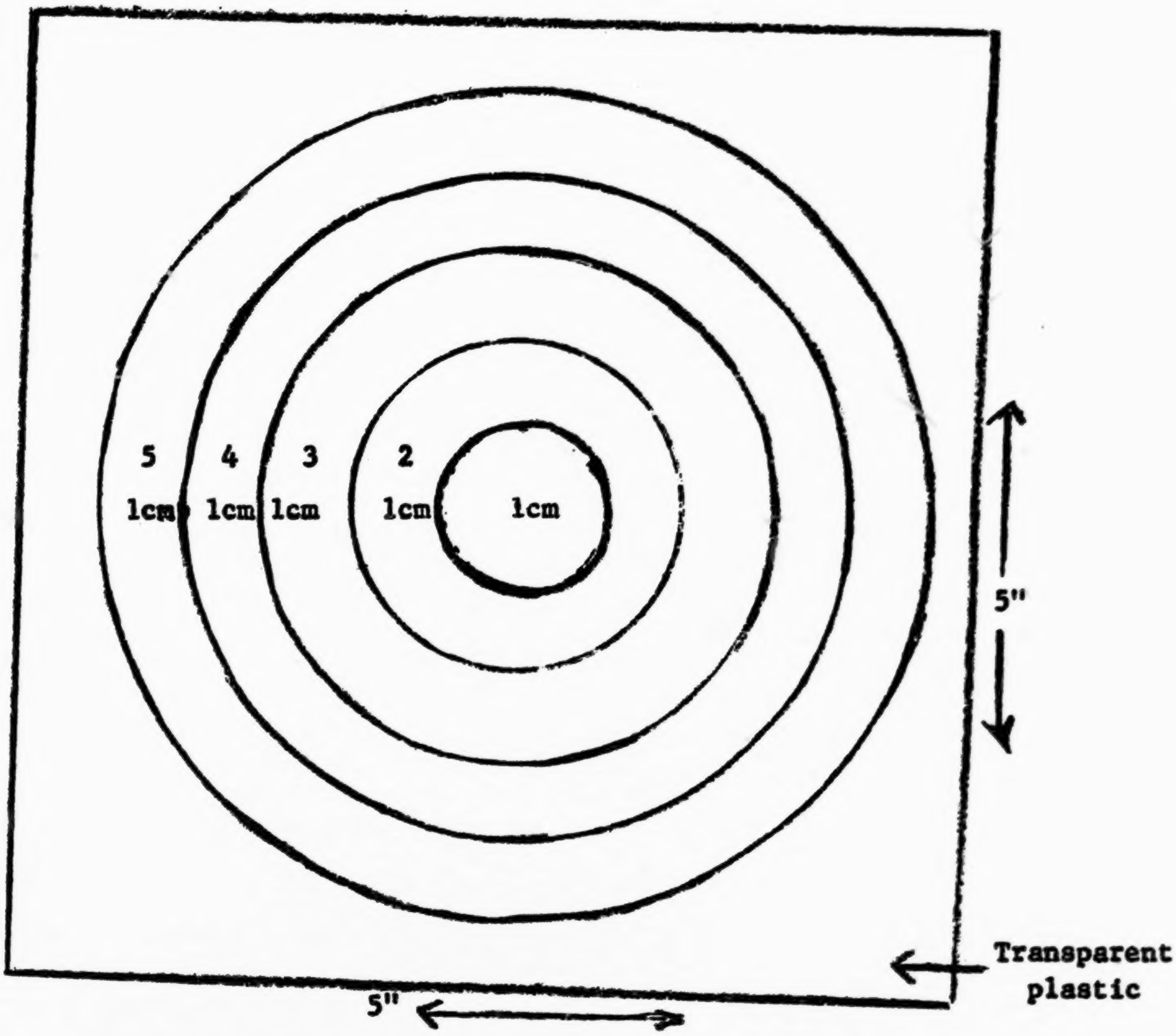
Demonstrate inoculation technique to entire class before activity begins. Sterilize inoculating needle by holding it over a bunsen burner until it is red-hot or glows. Allow the needle to cool for about 30 seconds and then touch the loop of the needle to the source of the inoculant very gently (do not dig into the inoculant) and transfer it carefully to the very center of the agar plate. Touch the agar plate very lightly with the contaminated loop of the needle. Close plate with cover and scotch tape immediately. Flame the loop of the needle each time it is to be used, or just after it has been used.

Prepare a candle jar: place all six petri dishes into a wide mouthed jar (gallon jar). Place one half of a petri dish on the top of the other six with a candle standing in it. Allow the candle to burn freely for several seconds and then seal the top of the jar. The candle will burn and then go out in a few seconds. Incubate this jar at room temperature without opening it. Do not place it in direct sunlight.

Plan to record data in chart given below:

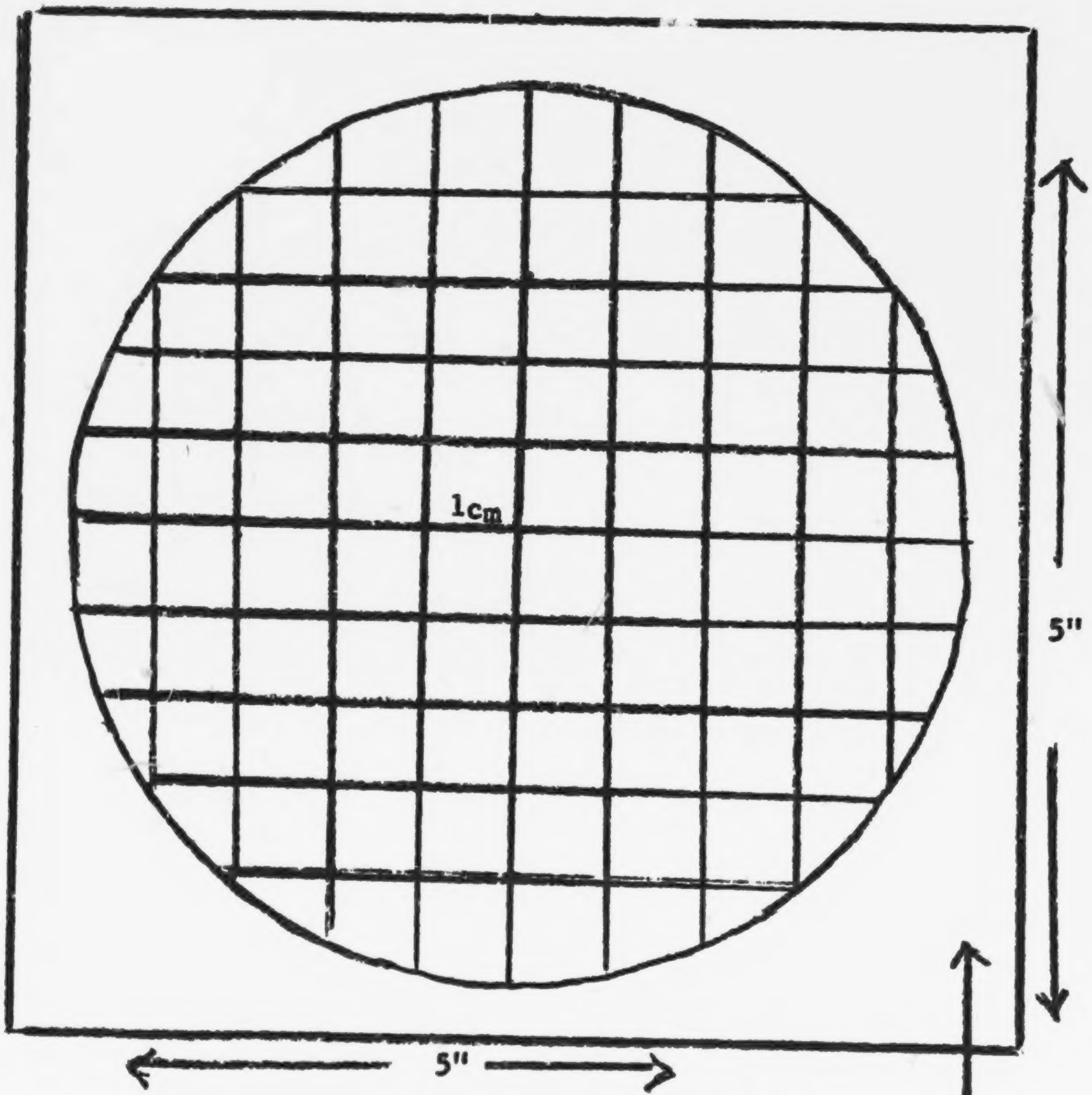
	Growth in cm	Color of Growth	Environment (CO_2) (Dark) (Light)	Other
Plate #1				
Plate #2				
Plate #3				
Plate #4				
Plate #5				
Plate #6				
Plate #7				
Plate #8				
Plate #9				
Plate #10				
Plate #11				

Prepare plastic counting disk by cutting design shown below onto transparent plastic material. Use compass to help draw concentric rings 1 cm. apart. Borrow cartooning ink from the art department and ink in the design.


5
4
3
2
1cm
1cm
1cm
1cm
1cm
5"
5"
Transparent plastic

Growth measuring disk

Prepare plastic counting disk by cutting design shown below onto transparent plastic material. Use compass to help draw concentric rings 1 cm. apart. Borrow cartooning ink from the art department and ink in the design.



Colony counting disk

Transparent plastic

CULTURE AND GROWTH OF SLIME MOLDS

PURPOSE

To study the growth patterns of slime molds and to observe their peculiar structure macroscopically and microscopically.

ACTIVITY MATERIALS

Rolled oats or oatmeal
Culture of slime mold
Teasing needle
Microscope
Vinegar
Probe
Heat source

WHAT TO DO

Culturing the slime mold:

Wrap a small finger bowl or petri plate with clean muslin or filter paper. Be sure that the material or filter paper is drawn smooth over the top of the finger bowl. Place this prepared bowl into a larger battery jar. Now add about 1 inch of water to the battery jar. The material or filter paper will act as a wick to keep the "drum" moist. Place the plasmodia (slime mold) into the top of the drum and sprinkle about one-tenth of a gram of pulverized outmeal or powdered instant oatmeal over the top of the drum. Cover the battery jar with a glass square. Observe in 24 to 48 hours. Avoid overfeeding.

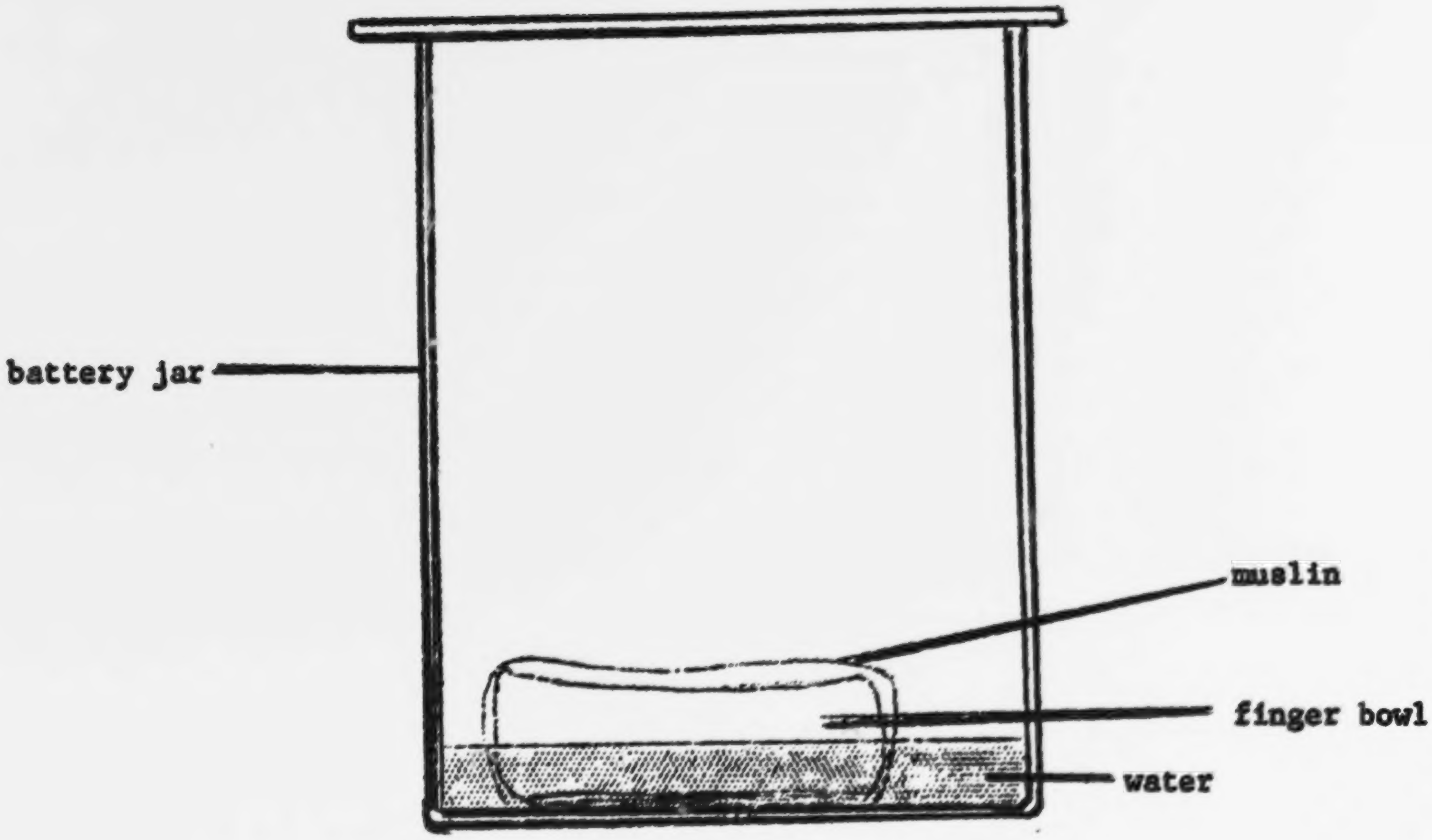
Alternate Method

Soak 6 gm of oatmeal in 200 cc of water for 1 hour. Strain the liquid. To a 100 cc of the clear filtrate add 1.5 grams of plain agar, and heat until the agar is completely dissolved. Pour a thin layer in several petri dishes. After media has harden add the plasmodia and observe from 24 to 48 hours later.

Students should observe the pattern of growth of the plasmodium under low power of the microscope and make several sketches of their observations.

Students describe the streaming motion of the cytoplasm in the plasmodium and structural organization.

Tear a small portion of one of the plasmodial strands with a needle, heat the needle and bring it near the plasmodium, sprinkle a small amount of oatmeal very close to the outer edge of the plasmodium, cut several pieces from the plasmodium but leave them close to the main body, touch another area of the plasmodium with a probe dipped in vinegar. What happens in each case?


battery jar
muslin
finger bowl
water

Culturing slime molds

References:

Morholt, Evelyn, P. F. Brandwein, and A. Joseph. Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958. pp. 386-387.

Adapted from BSCS, High School Biology, Green Version - The Laboratory, Exercise 11.1

STRUCTURE AND FUNCTION OF PARAMECIUM

PURPOSE

To study in detail the structure and function of a protozoan -- Paramecium

ACTIVITY MATERIALS

Yeast suspension
Congo-red solution
Microscope
Paramecium culture
Prepared slides of fission and conjugation
Methylene Blue stain
Slides and cover slips
Pipettes
Long vials or test tubes
Glass tubing
One-hole stopper
Aluminum foil
Four 1.5-volt dry cells and conducting wires
Two electrodes
Reversal switch
Dilute acetic acid

WHAT TO DO

Food Getting (Digestive Activity)

Prepare a thick suspension of yeast in water (about ½ cake of yeast in about 50 ml of water). Boil this mixture for about eight minutes, stirring gently to keep the mixture from burning. Add a small pinch of congo-red powder during the boiling period. Allow the mixture to cool.

Prepare a slide with a drop of Paramecia culture and a drop of yeast suspension. Allow 10 seconds to elapse. Observe under low power. Where are the stained yeast cells being taken in to the protozoan? Where are the food vacuoles formed? How can you tell the presence of the food vacuoles now? Trace the circulation of the food vacuoles in one Paramecium. What color is the food vacuole near the end of its circulation? Why? How long do you think it took for the color change to occur?

Protective Devices

Place a drop of Paramecium on a slide and cover. Add one drop of the dye to the slide on one end of the cover slip. Mix with one drop of water to make a 0.5% solution. Place absorbent paper at the opposite end of the cover slip so that capillary action will draw the methylene blue over the Paramecia. If the trichocysts are not discharged, tap cover glass gently with a pencil. The trichocysts should then "explode."

Movement

Prepare a slide with a drop of Paramecia culture and a drop of methyl cellulose and a trace of carmine powder. Cover and observe under low-power. Is the same end always in front? If so, describe the difference in shape of the front and back end?

What happens when the protozoan bumps into something?

Responses to Gravity and Light and Electricity

Prepare a culture of Paramecia and pour a portion into a test tube. Cover all but the top third section of the test tube with aluminum foil. Where do the Paramecia become concentrated? Are they positively or negatively geotropic? Positively or negatively phototropic?

Pass an electric current from one or two dry cells (1.5 volts) through a Paramecium culture by placing the ends of the wires 1 to 2 cm apart in a small watch glass containing the culture. The distance between the two wires can be increased to get the most striking responses. At which pole do the protozoans accumulate? Now reverse the current. Is there a change in direction of movement?

Add a drop of dilute acetic acid to a concentrated drop of culture of Paramecia. Observe under low-power. What is the reaction of the Paramecia? Is this a positive or negative tropism?

Correlating Structure and Function

You have now observed the Paramecium for a long period of time. Make a detailed drawing of a single animal and label all parts. Below the diagram describe the correlation of each structure labeled to its function.

A NONLIVING ANALOGUE TO DEMONSTRATE INGESTION, DIGESTION, AND EXCRETION

PURPOSE

To understand something about the mechanisms whereby an organism ingests some objects and excretes others.

ACTIVITY MATERIALS

Distilled water
6 inch test tubes
Chloroform
Glass rod
Shellac

WHAT TO DO

Place 2 inches of distilled water into a 6 inch test tube and drop 6 or 7 drops of chloroform into this. Swirl the water in the test tube and wait a minute for the chloroform to coalesce at the bottom to form a single more or less spherical drop about 1/8 inch across. Take a piece of glass rod about 1/8 inch thick, which has been pulled to a fine tip. *Be sure that the rod is* clean. Now insert the tip of the glass rod into the drop of chloroform. Does the drop accept the rod? Wipe the rod dry and dip the fine end into shellac. Allow this to dry. Now try again to make it enter the drop of chloroform. Does the drop accept it the first moment? Later?

Explanation: Teacher Reference

" . . . such a drop of chloroform under water, like that of mercury, approximates a spherical shape. It does so not so much because of its own surface tension but because of the surface tension of the water that surrounds it. Surface tension is a force well described by its name: the molecules of a fluid attract one another more or less strongly depending upon the substance of which it is composed, and at the surface, where this attraction is all directed inwardly, it produces a tension which tends constantly to contract the surface minimum. This is why such fluids tend when possible to assume the spherical form which presents the smallest possible surface for a given volume. Any distortion from the spherical form is resisted by the surface tension.

Glass is, of course, insoluble in chloroform, and the introduction of a glass rod would increase the surface of the drop. Its resistance to this increase of surface is the force that tends to expel the rod from the drop, or vice versa. The coating of the rod with a substance soluble to chloroform (shellac) entirely changes these relationships, since a coated rod no longer offers an incompatible surface to the chloroform, but instead a substance ready to enter the same phase with it. As a result, the drop now accepts the glass rod. In the happy event that the size of the chloroform drop and the amount of shellac on the rod come out about right, one might observe that after accepting the shellac-coated rod for a while, the drop spontaneously moves apart from it again. The explanation is that the drop has finished dissolving the shellac off the rod and now rejects the rod itself, as originally."*

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*Wald, George, Peter Albersheim, John Dowling, Johns Hopkins III, and Sanford Lacks. Twenty-Six Afternoons of Biology. Reading, Mass.: Addison-Wesley, 1962. pp. 10-11. (Reprinted with permission of publisher.)

MODERN CONCEPT OF A CELL
SHAPES AND SIZES
STRUCTURE AND FUNCTION OF CELL PARTS
CELLULAR PHYSIOLOGY

UNIT ONE: FOUNDATIONS OF LIFE

CONCEPTS TO CONSIDER:

Protoplasm is the physical basis of life

The cell is the unit of structure and function in all organisms

Every cell consists essentially of a mass of protoplasm which is usually differentiated into a central portion, the nucleus, and an outer portion the cytoplasm

Living cells require food and oxygen for energy and growth and must get rid of carbon dioxide, water and urea

Cells are organized into tissues, tissues into organs, organs into systems, the better to carry on the functions of complex organisms

The protoplasm of a cell carries on continuously all the general processes of any living body: the processes concerned in the growth and repair or upbuilding of cytoplasm (anabolism) and the processes concerned with the breaking down of cytoplasm and the elimination of wastes from the cell (catabolism). The sum of all these chemical and physical processes is metabolism.

Molecules of carbohydrates, fats, and proteins are large and complex and have high potential chemical energy

The four basic constituents in the cell's raw materials are carbon, hydrogen, nitrogen, and oxygen

Proteins are composed of amino acids bound together by an amide linkage, called a peptide

Carbohydrates are compounds containing the elements carbon, hydrogen, and oxygen with the ratio of hydrogen atoms two to one oxygen atom

Fats are composed of carbon, hydrogen, and oxygen with the ratio of hydrogen atoms to oxygen atoms always larger than two to one

All synthetic steps are enzyme-controlled

An enzyme is a protein that changes the rate of a chemical reaction but does not affect the nature of the final products

Enzymes are specific in the reactions they catalyze. In many cases there is a high degree of specificity

The energy-releasing process in cells is cellular respiration. In this form of oxidation, heat is the main form of energy given off, light is rarely released

All syntheses consume energy

All cells tend to build molecules from relatively few intermediate building units

All cell syntheses obtain energy and materials from sugar metabolism

The oxidation of glucose releases energy stored as chemical energy in energy-rich bonds of molecules of A T P

Reactions by which cells obtain energy occur in the mitochondria of the cell

A T P diffuses out of the mitochondria into the cytoplasm where it provides energy for movement, synthesizing cell substances and for all other cellular activities

The building up of a large molecule from simple building blocks is dehydration synthesis (losing water molecules)

When a large molecule is broken down into several smaller molecules the process is called hydrolysis (adding water molecules to the broken fragments)

The energy that supplies all life on the earth come ultimately from sunlight, through the process of photosynthesis

The pigments which absorb the light used in photosynthesis are found in the chloroplasts of green plants

The principal pigment of chloroplasts is chlorophyll a

The net action of light in photosynthesis is to supply the required energy to split water

Photosynthesis is a series of events in which the elements carbon, hydrogen, and oxygen are joined in such a way that the resulting product is carbohydrate

Regardless of which other pigments absorb light, only chlorophyll a can transfer energy into photolysis, water splitting reaction.

Red-orange and blue-violet light absorbed by the chlorophyll molecule causes some electrons within the chlorophyll atom to jump from its normal orbit to a new orbit farther away from the atomic nucleus and in this way the chlorophyll is able to trap light energy

TEACHING APPROACH: (Methods and Activities)

Discuss shapes and sizes of cells

- Explain the limitations of size and form according to the surface area - volume ratio using activity on p. 99
- Assign some students to make a visual cell out of jello. See p. 100
- Discuss and allow students to read original writings of Robert Hooke using book Gabriel and Fogel, "Great Experiments in Biology"
- Students "look over the shoulder" of great biologists and recreate Robert Hooke's experiment of cork observation. See p. 101
- Students observe various plant and animal cells making observations of shapes and sizes (whenever this can be done)
- Assign one student group to prepare large cutouts of the various cell shapes seen under the microscope. Display these cutouts on the flannel board or on a bulletin board entitled "A cell is a cell is a cell....."

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Discuss the structure and function of cell parts

- Use a flannel board demonstration to show the cell and its parts. Students use Biology study chart # THE CELL to learn the structure of a cell
- Make a comparison beteeen a plant and animal cell using a chart shown below:

PLANT	ANIMAL
1. Cell wall and cell membrane	1. No cell wall, cell membrane
2. Cellulose deposits	2.
3.	3.
4.	4.
5.	5.

- Discuss the structure and function of cell wall and cell membranes
- Relate active transport, osmosis, and other types of molecular movement through membranes
- Demonstrate osmosis by methods suggested on pp. 105-107
- Students make observations of osmosis and plasmolysis in living cells. See p. 108-109
- Discuss the structure and function of cytoplasm. Use raw egg white to demonstrate cytoplasm. Exhibit the "sol" state by pouring it into a beaker. Exhibit the "gel" state by pouring some into boiling water
- Demonstrate the meaning of colloidal suspensions. See p. 112-113
- Demonstrate sol-gel reversibility by using agar, melted (sol) and solidified (gel) and then melted again
- Students locate the approximate sizes of the following cells and try for a scale representation for a good bulletin board display. Ostrich egg, hen egg, hummingbird egg, human egg, amoeba, sea urchin egg, liver cell, red blood cell, typhoid bacillus, influenza bacillus, pneumococcus bactrium, bacterial virus, hemaglobin molecule (Swanson, C. "The Cell", pp.22)
- Discuss the mitochondria, ribosomes, golgi complex, and endoplasmic reticulum

Discuss cellular physiology

- Discuss the necessary nutrients needed by the cell. Students make a list of nutrients
- Students make various tests on organic nutrients (foods) by use of chemical detectors. See p. 110-111
- Prepare a flannel board demonstration on the ATP-ADP cycle
- Discuss cellular respiration. Have students perform experiment concerned with a part of cellular respiration to show the enzyme reaction in one step of the Krebs Cycle. See p. 118-119

- Bring out the concept of the specificity of enzymes (one enzyme catalyzes one chemical reaction).
- Students perform experiments to show the action of amylase and its relation to rate of decrease and increase in temperature and dilution. See pp. 114-116.
- Discuss the irreversibility of certain chemical reactions in cellular respiration. Students prepare an experiment to show the possibility of reversibility of an enzyme. See pp. 118-119.
- Discuss how living organisms are able to utilize energy produced. Encourage students to give reports concerning nerve impulses, muscle contraction, bioluminescence, and synthesis of macromolecules.
- Discuss photosynthesis. (Photolysis and CO_2 fixation.)
- Students perform experiment on p. 122 to learn about light absorption.
- Prepare a bulletin board that will visualize light radiations, visible and nonvisible, giving the lengths of waves. Include the spectrum of light as seen through a prism.
- Students learn to separate chlorophyll extract by paper chromatography.
- Prepare a flannel board demonstration to relate to chromatograms aiding students in being able to identify bands of separated molecules.
- Grow purple bacteria and discuss other types of biosynthesis.
- Students compare light intensity and rate of oxygen production in photosynthesis by use of volumeter. See pp. 128-129.
- Discuss recent developments in photosynthetic research. Students read articles about research and give reports to the class on their readings.
- Students do experiments to show that starch is produced by the process of photosynthesis. See pp. 130-131.

DEPTH PROBE

- LIMITATIONS OF CELL SIZE, pp. 99. (Average Student Basic Activity). Explains the concept of cell size limitations and mathematics involved. Teacher demonstration.

- "JELLO-CELLO", p. 100. (Slow Student Basic Activity - Slow Student). A visual demonstration of a cell and its parts. Student or teacher demonstration.

- OBSERVATIONS OF CELLS IN CORK, p. 101. (Average Student Basic Activity). Observing cork cells in much the same way as Robert Hooke did in 1665. Students work in pairs.

- OBSERVATIONS OF DIFFERENT SHAPES OF CELLS, pp. 102-103. (Average Student Basic Activity). To observe basic differences between plant and animal cells and to be exposed to a variety of shapes and sizes in cells. Students work in pairs.

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- LEARNING THE PARTS OF A CELL, p. 104. (Average Student Basic Activity - Slow Student). A flannel board demonstration of cell structure and function. Teacher or student demonstration.

- OSMOSIS, p. 105. (Average Student Basic Activity). To demonstrate diffusion of molecules through a semipermeable membrane. Teacher and student activity. (Group.)

- ALTERNATE METHODS TO DEMONSTRATE OSMOSIS, pp. 106-107. (Average Student - Optional). Classical methods used to demonstrate diffusion through a semipermeable membrane. Teacher demonstration.

- OSMOSIS IN LIVING CELLS, pp. 108-109. (Average Student Basic Activity). Demonstrates the effects of plasmolysis and osmosis in living cells. Students work in pairs.

- FINDING ORGANIC NUTRIENTS, pp. 110-111. (Average Student Basic Activity). Using chemical detectors to identify nutrients in living cells. Students work in group or teams.

- COLLOIDAL SUSPENSIONS, pp. 112-113. (Average Student Basic Activity). Analyzing liquid-solid systems and gaining an understanding of sol-gel ability of protoplasm. Students work in groups or teams - or teacher demonstration.

- ENZYMIC ACTIONS, pp. 114-116. (Average Student Basic Activity). Understanding about the functions of enzymes in living tissues - and their specificity for a narrow band of catalysis. Students work in teams.

- CELLULAR RESPIRATION, p. 117. (More able Student-Basic). Demonstrate the action of dehydrogenase in cellular respiration. Students work in teams.

- PHOSPHOROLYSIS, pp. 118-119. (More able Student - Optional). Demonstrating the concept of enzyme reaction and its reversibility. Students work in teams.

- "HILL REACTION", pp. 120-121. (More able Student Basic Activity). Demonstrate light energy as needed in photolysis. Students work in teams.

- ABSORPTION OF LIGHT ENERGY, p. 122. (Average Student Basic Activity). To understand absorption, reflection, and composition of light in relation to photosynthesis. Teacher or student demonstration.

- STUDYING GREEN PIGMENTS WITH PAPER CHROMATOGRAPHY, pp. 123-126. (Average Student Basic Activity). Learning about chlorophyll through a special technique of paper chromatography. Students work in pairs.

- BACTERIAL PHOTOSYNTHESIS, p. 127. (More able Student - Basic Activity). To demonstrate that certain bacteria are able to use light energy for photosynthesis. Students work in teams.

- LIGHT AND PHOTOSYNTHESIS, pp. 128-129. (More able Student - Basic Activity). Light intensity will limit the rate of photosynthesis. Students work in teams.

- PHOTOSYNTHESIS, pp. 130-131. (Average Student Basic Activity). Factors necessary for photosynthesis. Students work in teams.

PLANNING AHEAD

- Collect specimens of various plants and animals for display. See p. 141.
- Locate and reserve bones of the leg or arm of a frog, lizard, fish, and others. See p. 142.
- Prepare ditto sheets with drawings on pp. 142-143.
- Make plans with a student group to do a bulletin board entitled VARIETY IS THE SPICE OF LIFE. Collect cutouts and pictures of various plants and animals.
- Order green hydra, planaria, and frogs from Science Center.
- Assign students the task of collecting crayfish and live earthworms.
- Encourage some students to bring in their pet rat or hamster for experiment on p. 169.
- Collect nails, bolts, and screws of different shapes for exercise on p. 149.
- Make cutouts of geometric figures for flannel board demonstration on p. 144.
- Assign a student to the preparation of food signs for the "International Grocery Store."
- Collect and borrow sponge specimens.
- Locate and reserve filmstrip CAROLUS LINNAEUS (Blue Box collection in your Science Department.)
- Prepare a display of homologous structures and their analogues.
- Assign student reports on Linnaeus, Buffon, Lamarck, and others.

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UNIT ONE: FOUNDATIONS OF LIFE

BROADENING "CONTENT HORIZONS"

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- Lindstrom-Lang, K. U. "How Is a Protein Made?" (Sept. 1953)
- Pauling, Linus, Corey, Robert, and Hayward, Roger. "The Structure of Protein Molecules," (July 1954)
- Schmitt, Francis O.. "Giant Molecules in Cells and Tissues," (Sept. 1957)
- Stein, William, and Moore, Sanford. "Chromatography," (March 1951)
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- Kendrew, John. "The Three-Dimensional Structure of a Protein Molecule," (Dec. 1961)
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- Hoffman, J. G. Life and Death of Cells. New York: Hanover House, 1957.
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LIMITATIONS OF CELL SIZE

PURPOSE

To explain the concept of cell size limitations and the mathematical concepts involved.

ACTIVITY MATERIALS

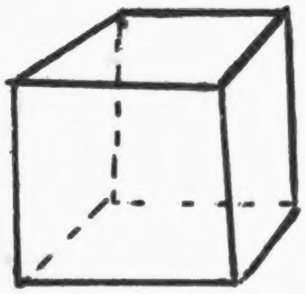
Cubical counting blocks (set of 100 borrowed from Math Department, if available)
Plastic spheres (three sizes as explained in next section)
Cardboard cubes (three sizes as explained in next section)
Wood spheres (three sizes as explained in next section-dissectable into two hemispheres)
Heavy cord Sand and/or water Tack

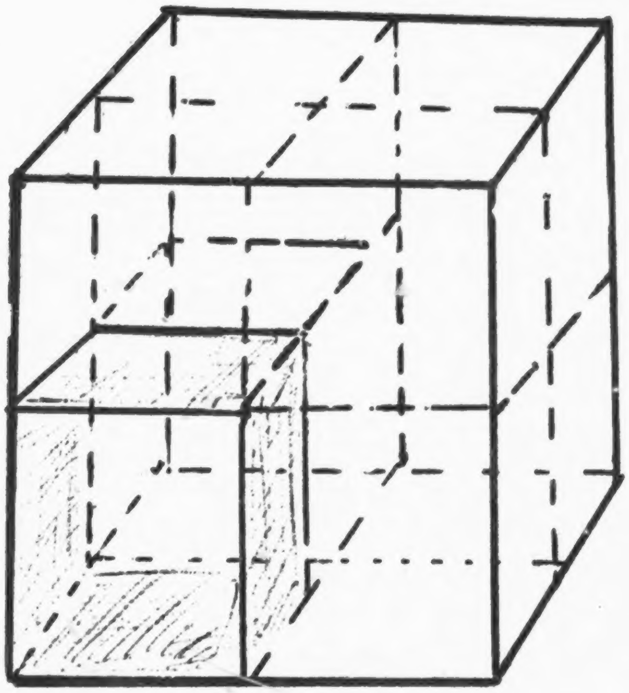
WHAT TO DO

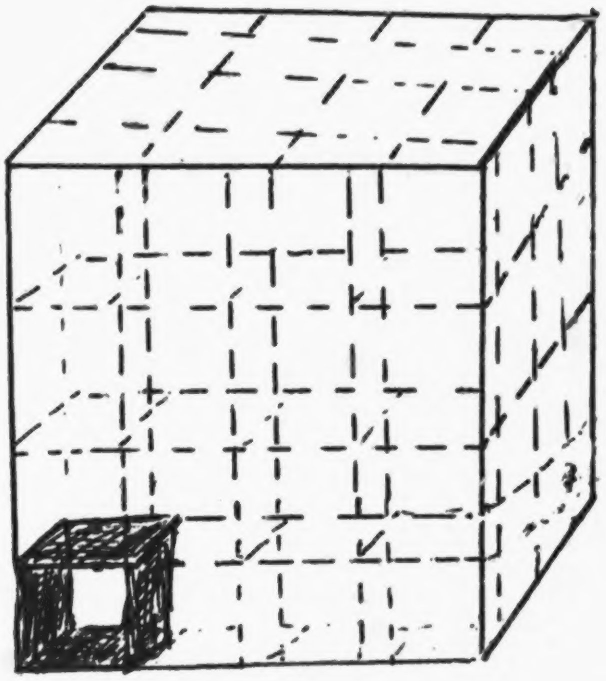
Prepare three cardboard cubes of varying sizes. Leave one side open on each cardboard cube. The dimensions of the cardboard cubes are as follows, (1) cardboard cube #1 measures 1" X 1" X 1"; cardboard cube #2 measures 2" X 2" X 2"; cardboard cube #3 measures 4" X 4" X 4".

Using 1" cubical counting blocks, students determine the number of cubical counting blocks that will fit cardboard cube #1, #2, and #3. How many times larger is cardboard cube #3 than #1, #3 than #2, #2 than #1.

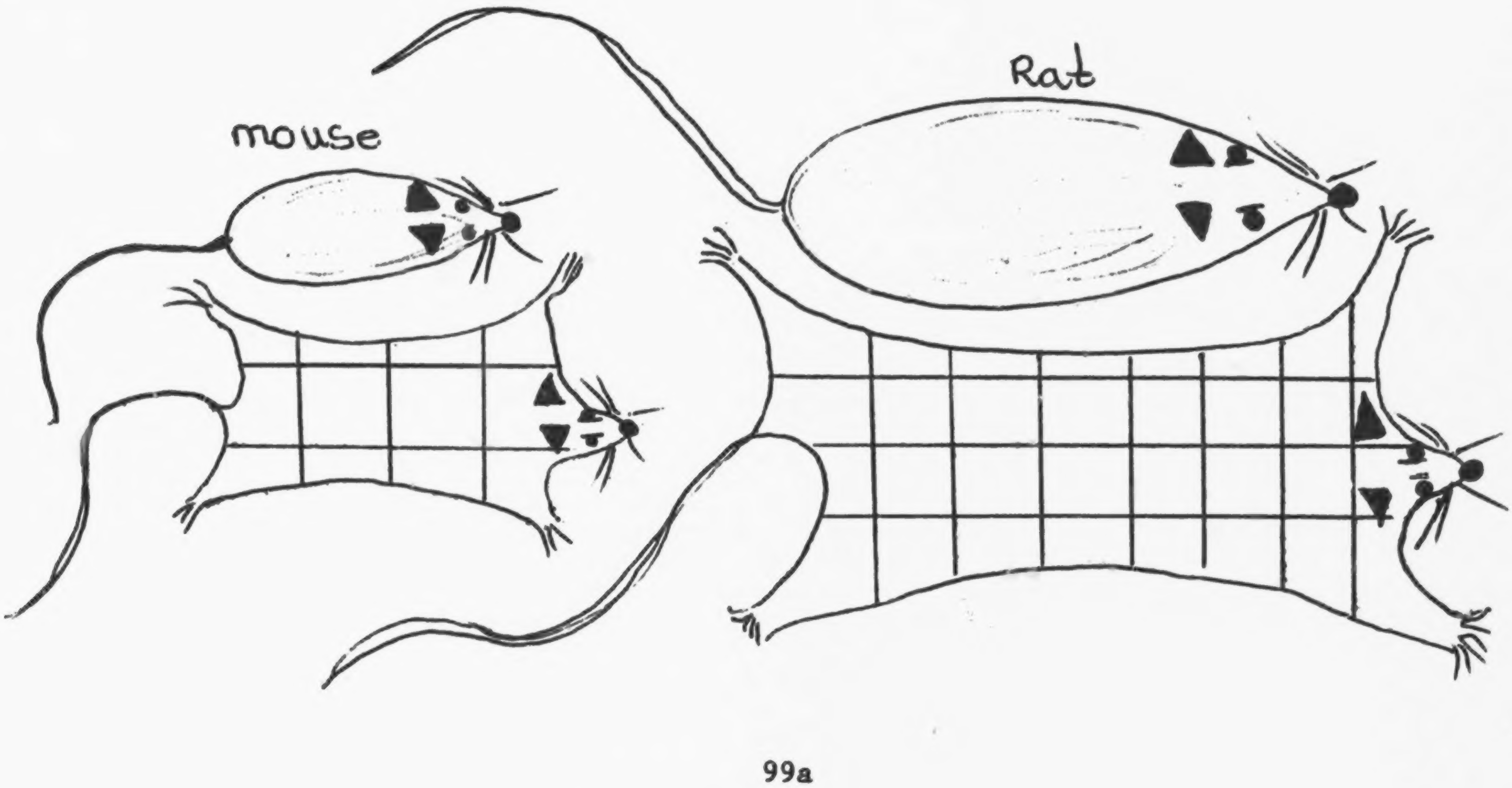
Correlate the surface-volume relationship in each of three cardboard cubes (#1), (#2), and (#3).





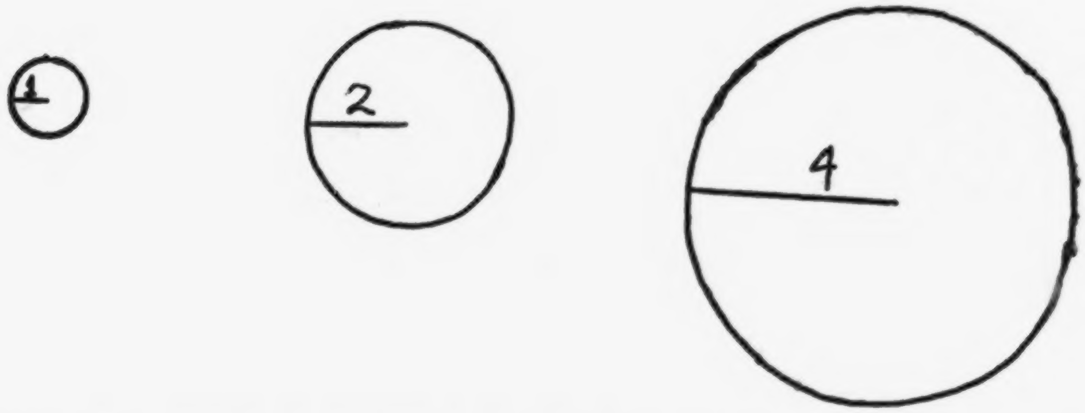


What is the relationship of the surface-volume in the mouse and rat diagram? The length of mouse is 1/2 that of the rat and its volume is 1/8 that of the rat, what is its surface relationship?

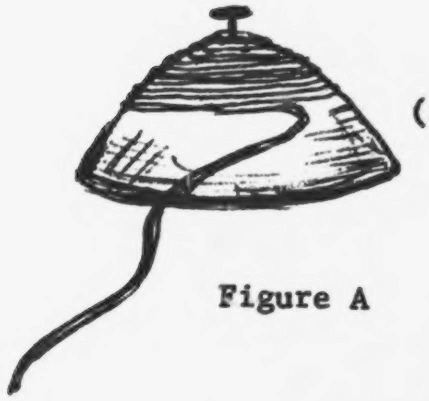


Alternate method

Using three wood spheres of the following dimensions: (1) having a radius length of one inch (2) having a radius length of two inches (3) having a radius length of four inches. How many times larger is the length of radius of sphere number three than one? of sphere number three than two? of sphere number two than one?

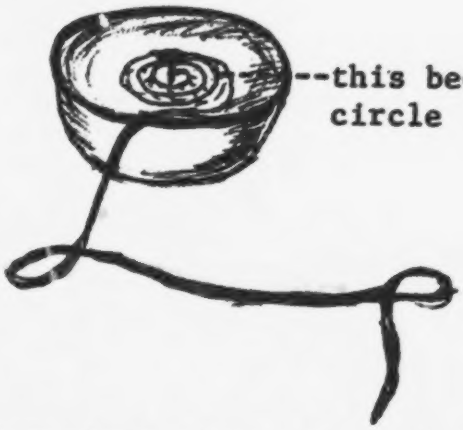


To demonstrate the difference between the area of a circle and a sphere. Using just half of a wood sphere, place a tack directly in the center holding a piece of thick string. Carefully wrap the string around the tack until the entire flat surface is covered. Measure the length of the string needed to do this? Now place a tack at the top of a half curved sphere and carefully wrap thick string around the tack until the lower surface is covered. Measure the length of the string. What is the difference in surface of the curved surface and the flat surface? ($S = 4\pi r^2$)



($S = 4\pi r^2$)

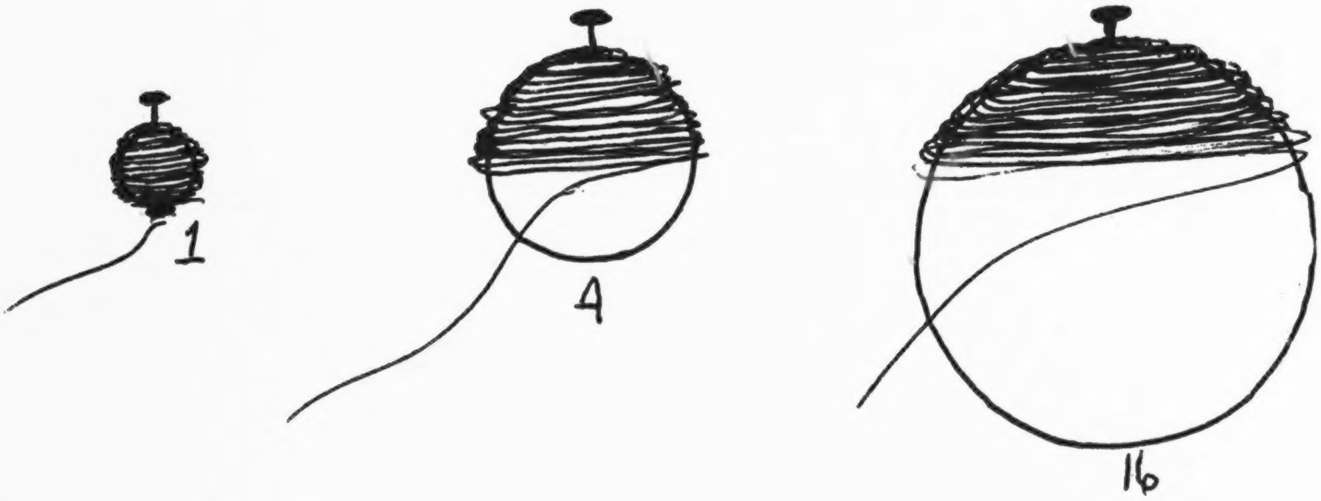
Figure A



--this becomes the area of a circle $A = \pi r^2$

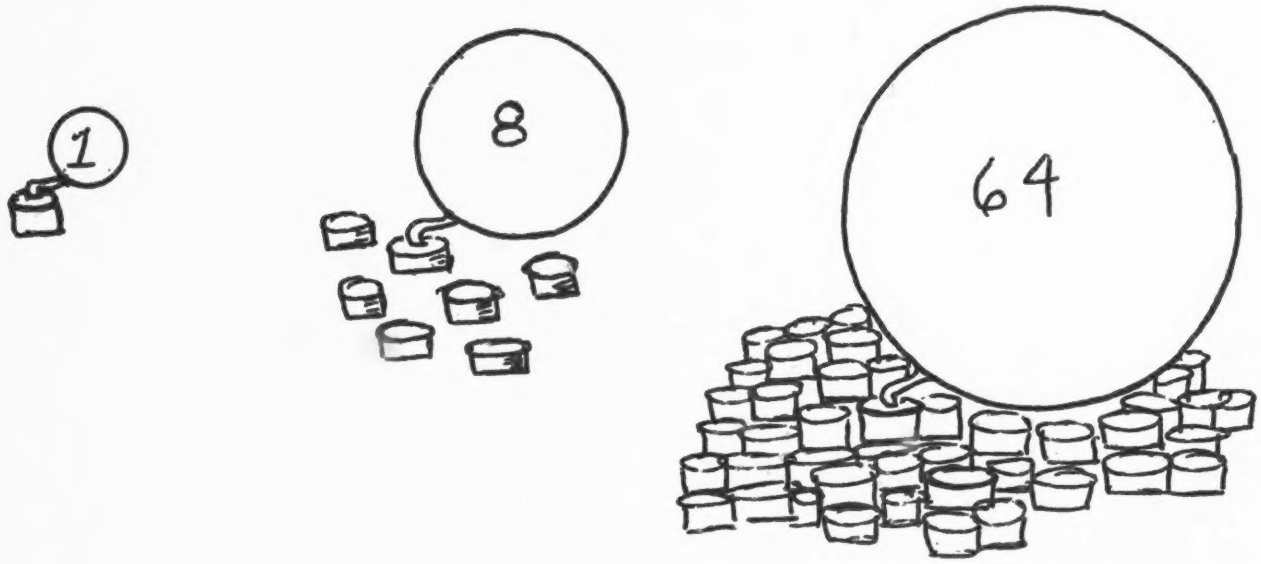
Using the three wood spheres of the dimensions given above cover the entire sphere with string as suggested in Figure A. Measure the amount of string needed to cover the first sphere? Second sphere? Third sphere?

What is the ration of $S_1 =$ $S_2 =$ $S_3 =$?



Using three plastic spheres (if available in sizes suggested for three wooden spheres) pour sand or water into sphere number one. How many portions of sand in number one fills sphere number two? How many portions of sand from sphere number one fills sphere number three? What is the volume ratio of ($V = \frac{4}{3}\pi r^3$)

$V_1 \quad : \quad V_2 \quad : \quad V_3 \quad ?$



JELLO-CELLO

PURPOSE

To help students visualize the cell and its parts

ACTIVITY MATERIALS

Clear powdered gelatin
Maraschino cherry (red or green)
Tiny beads of varying color
Plastic circle larger than the cherry
Square or round mold no larger than a luncheon plate
Cigar-shaped objects
Laminated objects

WHAT TO DO

Prepare the clear gelatin (or jello) in the same manner as you would for making a dessert. Pour ½ of gelatin into a square (or round) mold. Allow gelatin to become semifirm by placing in the refrigerator for several hours. Add the maraschino cherry and plastic ring so that each will represent a part of the cell (maraschino cherry, the nucleolus, and the plastic ring, the nucleus) in the proper place in the cell. Add tiny beads to represent granules and cigar-shaped objects to represent the mitochondria, small laminated objects to represent the golgi complex. Now pour the remainder of the clear gelatin over this very carefully so that the items will not move. Replace the mold in the refrigerator and keep there until preparation is completely firm and can be removed as a whole piece. When the cell demonstration is ready to be used, remove the mold from the refrigerator and immerse container in a hot pan of water for several seconds so that the mold will be released slightly from it. Place a plate over the container and turn the mold upside down onto the plate.

OBSERVATION OF CELLS IN CORK

PURPOSE

To observe cork cells in much the same way as Robert Hooke first did in 1665

ACTIVITY MATERIALS

Razor blade
Microscope
Microscope slide and cover slip
Bottle cork
Detergent solution

WHAT TO DO

Cut thin sections from the bottle cork with the single-edge razor. Be careful of your fingers. When an extremely thin section has been cut, mount this on your slide and use the detergent solution as the mounting fluid, Use cover slip on this and observe under low power. Because it is very difficult to make thin freehand sections you'll have to look along the thinnest edges of the specimen for the clearest view of cork structure.

Draw several cells from your specimen. Do you think the cells of cork are living or dead? Do you think your drawing is comparable to the drawing that Hooke made of the cork structure?

OBSERVATION OF DIFFERENT SHAPES OF CELLS (Plant and Animal)

PURPOSE

To observe microscopically a variety of plant and animal cells and to determine some differences between plants and animals through these observations.

ACTIVITY MATERIALS

Microscope
Slide and cover slips
Dissecting needle
One or two live frogs
Pipettes
Saline solution in dropping bottles
Celery stalks or rhubarb stalks
Iris leaves
Razor blades (single-edge)
Prepared slides of leaf, stem
root cross section
Human blood
Any other types of cells

WHAT TO DO

Observing Plant Cells

Remove a vein from a celery stalk, mount it in a drop of water on your slide. Use another slide to cover over the drop and vein by pressing hard to flatten out the vein (the vein is now sandwiched between two slides). Observe under low power and make a sketch of your specimen. Write a description of shape and tell something about how you would relate its function to its shape (structure). Use stems of asparagus or stems of rhubarb to show variety of types. See p. 67

Remove a piece of lower epidermis from a leaf and place it in a drop of water on a slide. Cover with cover slip and observe under low power. Sketch and label parts that you know. Write a description of the structure and correlating the function of this particular specimen. (See p. 67 for further variety of type in lower epidermis.)

Remove the furry material (hairy material) from a geranium leaf and observe this under low power. Give a description of correlating structure and function of these cells.

Examine any prepared slides of cross sections of roots, stems and leaves, make drawings of cells and give a statement as to the correlation of structure and function of some cells you may see for the first time on these prepared slides.

References
- Morholt, Brandwein, Joseph. *Sourcebook for the Biological Science*, For Pithing Technique. Removing Gastrocnemius, pp. 128, 129, 131, fig. 9-7. Ibid.

OBSERVATION OF DIFFERENT SHAPES OF CELLS (Plant and Animal)

WHAT TO DO

Observing Animal Cells

Prepare Ringer's Solution (Physiological salt solution)
KCl 0.14 g, NaCl 6.50 g, $CaCl_2$ 0.12 g and $NaHCO_3$ 0.20 g dissolved in one liter of water.

To Be Done by Teacher.
Prepare the following tissues for observation under the microscope. Use a freshly killed frog. In each of six petri dishes place blood (suspended in sodium citrate or Ringer's solution), skin(or skin that has been shed in water in which frog has been kept),ciliated epithelium, muscle, sperm, and nerve tissue.

Prepare 6 slides:

1. Prepare a blood slide by taking a drop of the blood suspension and adding a drop of methylene blue and cover slip. Observe under low and high power. After examination make drawing of some cells under low power.
2. Scrape skin cells from frog skin onto a drop of Ringer's solution and add a drop of methylene blue and cover slip. Observe under low power and make a sketch of observation showing several skin cells.
3. Cut or scrape a piece of tissue from the roof of a frog's mouth. Place in a drop of Ringer's solution, cover and observe under low power. Now observe under high power. Describe and make a sketch of observation.
4. Cut the gastrocnemius muscle from the frog's leg and tease a section of the muscle apart with teasing needles in Ringer's solution. Place a small teased section on the slide in a drop of Ringer's solution and add methylene blue and cover slip. Carefully press down on cover slip to flatten the teased muscle. Observe under low power and make a sketch of the specimen.
5. Carefully dissect out a nerve place the nerve tissue on a slide. Take another slide making a sandwich and press these together to mash the nerve tissue. Remove the two slides and allow the nerve tissue to dry. Stain with methylene blue. Observe under low power and sketch the specimen.
6. Remove the testes from the frog. Chop the testes with a sharp scalpel and transfer to a watch glass of 0.3% solution of sodium chloride in distilled water. Tear the testes with teasing needles and swirl it around in the solution until the solution has a milky appearance. Mount drops of this fluid onto a slide add a cover and observe under low and high power. Make a sketch of your observation.
7. Observe other prepared slides that are available to show a variety of shapes and sizes in animal cells.

LEARNING THE PARTS OF A CELL BY FLANNEL BOARD TECHNIQUE

PURPOSE

To aid students in learning about the parts of a cell and function of these parts through a visual aid, the flannel board

ACTIVITY MATERIALS

Flannel board
Cutouts of cell and parts
Construction paper of various color
Flocking paper cut into strips for backing cutouts
Scissors

WHAT TO DO

Prepare cutouts of the parts of a cell in various colors of construction paper. Nucleus in orange, cell wall in green, cell membrane in lighter green, nucleolus in light orange, chloroplasts in green, mitochondria in red, and any other colors for other parts not mentioned. Make large labels for each part on yellow construction paper. Place strips of flocking paper on each cutout and including the labels.

Place the cutouts of the cell out of sequence on the flannel board. Choose one student at a time to place one cutout in its proper place inside of the cell wall. After every part has been put in place choose a single student at a time to remove a part of the cell and place it along the flannel board with its proper label. When all of the labels and cell parts have been matched, choose students one at a time to select one part and its label and recite to the class all information about his selection.

OSMOSIS

PURPOSE

To demonstrate the process of diffusion through a semipermeable membrane

ACTIVITY MATERIALS

- Cellulose tubing (sausage casing)
- Soluble starch
- Glucose solution (80% solution)
- Ringstand
- Burette clamp
- Large beakers
- Benedict's solution
- Iodine-Potassium-Iodide Solution
- One-ml pipettes or glass tubing
- Clinitest tables or Tes-Tape

WHAT TO DO

Cut sausage casing into lengths of nine inches each. Carefully tie a knot at one end or wind a rubber band around until it is completely closed. Fill this tube with soluble starch solution to within 6cm of the top. Add 1 ml of glucose solution (or about 20 drops with pipette). Pinch the top of the tube together tightly and mix the contents together carefully. Flush the outside of the tube in clear water to remove any excess glucose and starch solution. Tie securely and place in a beaker of water containing 2 ml of iodine. Allow this to stand for several minutes (5 minutes) and make notation of change....check in 10 minutes and make a notation of any change. Test water in beaker with Clinitest Tablets or Test-Tape for presence of glucose and iodine for the presence of starch.

Cut sausage casing into a nine-inch length and carefully tie a knot at one end or wind a rubber band around until it is completely closed. Fill this tube with soluble starch solution adding about 2 ml of saliva. Tie securely at the top end and place in a beaker of water. Observe in 15 minutes.... Remove some of the water from the beaker, add several drops of Benedict's solution and test for glucose.

Cut sausage casing into a nine-inch length. Carefully tie a knot at one end or wind a rubber band around until it is completely closed. Fill this tube with glucose solution and attach a 1 ml pipette to the top of this casing very securely with string or rubber band. Fasten the pipette to a ringstand with a burette clamp and place the sausage casing tube into a beaker of water. Record the rising column at two minute intervals and plot results on a graph.

NOTE:
When testing with Clinitest Tablet, add a drop of liquid to a fragment of tablet or in using Tes-Tape dip the tape into the liquid. Yellow color indicates glucose.

- Lawson, Chester, R. Lewis, Burmester, M.A., Hardin, G. Laboratory Studies in Biology. San Francisco: Freeman Co., 1958. pp. 27-32.
- Yellow Version, BSCS Laboratory Manual pp. 55-59.

ALTERNATE METHODS TO DEMONSTRATE OSMOSIS

PURPOSE

Using several methods to demonstrate diffusion through a semipermeable membrane

ACTIVITY MATERIALS

- Raw egg
- Glass tube
- Sealing wax
- Beaker
- Semipermeable
- Membrane
- String
- Ringstand
- Burette clamp
- Cotton
- Raw potato
- Raw carrot
- One-hole rubber stopper
- Thistle tube
- Karo syrup (colored)

WHAT TO DO

A. Fill the bulb of a thistle tube with karo while holding forefinger over end of tube. (This prevents syrup from running down tube.) Fasten a piece of pig's bladder (which has been soaked for several hours in water) over the bulb of the thistle tube with a piece of string. Invert the bulb into a beaker of water. Fasten it into position by using a burette clamp and ringstand. Mark the level of Karo syrup and note time. How long did it take for a change in Karo syrup level? (Fig. 1)

B. Remove the hard shell membrane from one end of a raw egg (do this very carefully to leave the inner shell membrane intact.) Remove the hard shell and inner shell membrane from the other end of the egg. Insert a glass tube halfway into egg (a one ml pipette will do). Seal the glass tubing to the egg with sealing wax or paraffin. Be sure it is sealed tightly. Fasten burette clamp to a ringstand after egg has been inverted into a beaker of water so that the inner shell membrane is slightly below the water level. Mark the level of egg yolk or albumin on glass tubing. (Fig. 2)

C. Hollow out a raw carrot or potato. Be sure the top of the hollowed part is no larger than a one-hole stopper. Fill the hollowed part with karo syrup or a sugar solution that has been colored. Insert the one-hole rubber stopper in top of carrot or potato with glass tube (a one ml pipette will do). Seal stopper to carrot or potato with sealing wax or paraffin. Cut a flat surface on the other end of the vegetable and insert into a beaker of water. Fasten it into position by using a burette clamp and ringstand. Mark level of Karo syrup on glass tubing and note time it takes for this level to change. (Fig. 3)

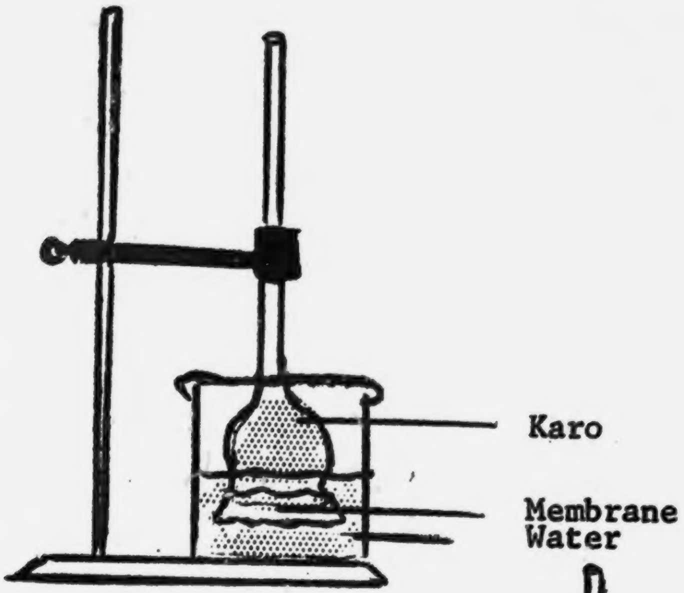

Karo
Membrane
Water

Figure I

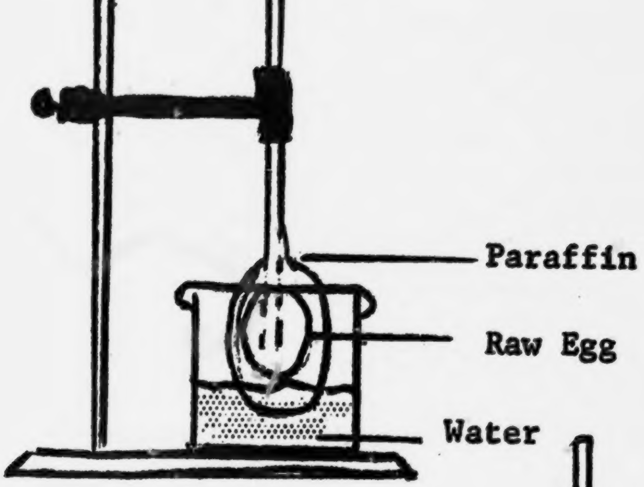

Paraffin
Raw Egg
Water

Figure II

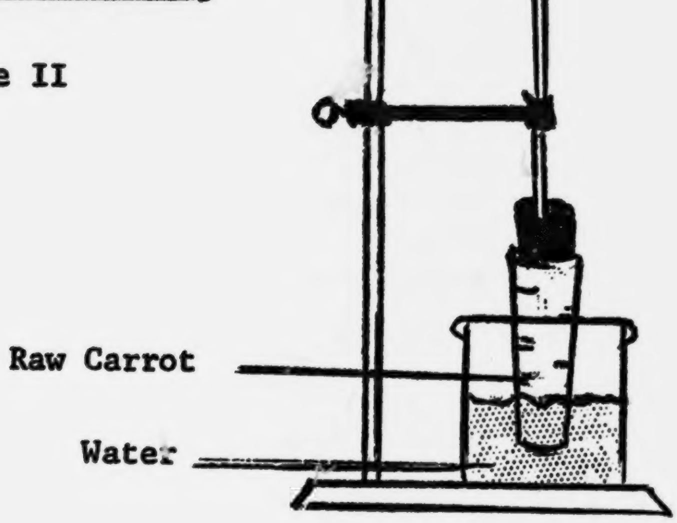

Raw Carrot
Water

Figure III

OSMOSIS IN LIVING CELLS

PURPOSE

To demonstrate the ability of cell membranes to exhibit selective permeability

ACTIVITY MATERIALS

Elodea (Anacharis)
Yeast solution
Congo red dye

Sugar solutions of varying strengths
0.05% NaCl solution
Microscope

Slide and cover slip
Test tube racks
0.1% (10%) Formaldehyde solution

WHAT TO DO

A. PLASMOLYSIS

Prepare a microscope slide with a leaf from the growing tip of an Elodea sprig. Add a drop of water and cover slip. Observe under low power and high power. Is there any movement of cytoplasm? of Chloroplasts? Why? Is the movement, if any, in the same direction in all cells of Elodea leaf?

Prepare on one slide a drop of 80% glucose solution and one of a 5% salt solution. Add a leaf from the growing tip of an Elodea sprig to each drop and cover. Observe under low power. What do you see taking place? What happens in the sugar solution? What happens in the salt solution?

Place the two leaves in fresh water for about five minutes. Observe them both under the low and high power. What has happened? Why?

B. SELECTIVE PERMEABILITY OF LIVING MEMBRANES

Prepare a fresh solution of yeast cells and put 2 ml of this solution in each of three test tubes. Mark each test tube with freezer tape or wax pencil. Test tube 1, test tube 2, test tube 3.

In test tube #1 add 2 drops of congo red solution. Heat this to a boiling point. In test tube # 2 add 2 drops of a 10% solution of Formaldehyde and 2 drops of congo red solution. Mix carefully.
In test tube #3 add 2 drops of congo red solution

Now place a drop of each of the solutions on a microscope slide and observe under low and high power. Be sure you do not allow the three drops to run together. Cover with cover slips.

From your observations of the three solutions answer the following:

Which of the solutions show red-stained cells?
Which of the solutions show cells that have not accepted the red stain?
Why is there a difference in red stain acceptance?

References:

- Lawson, Chester, Lewis R., Burmester, M.A., Hardin, G. Laboratory Studies in Biology. San Francisco: W.H. Freeman and Co., 1958. pp. 32-33.
- Machlis, Leonard, and Torrey, John. A Laboratory Manual of Plant Physiology. San Francisco: W.H. Freeman Co., 1959. pp. 61-62.
- Yellow Version, BSCS Laboratory Manual p. 62.

FINDING ORGANIC NUTRIENTS

PURPOSE

Using chemical detectors to identify nutrients present in living cells (food)

ACTIVITY MATERIALS

- Bread
- Meat
- Milk
- Banana
- Potato
- Apple
- Grape
- Butter
- Others
- Benedict's solution
- Biuret Reagent
- Iodine solution
- Test tubes
- Bunsen burner
- Microscope
- Slide and cover slip
- Beakers
- Glass stirring rod
- Unglazed paper
- Ammonium hydroxide
- Dilute nitric acid
- Pipettes

WHAT TO DO

Cut an extremely thin wedge of raw potato and place on a slide in a drop of water. Add cover slip and observe under low and high power. Add iodine solution to the slide (place it along the edge of the cover slip). What reaction takes place? What color were the plastids before staining?

Cut a very thin wedge of raw apple and place on a slide in a drop of water. Add cover slip and observe under low and high power. Is there any indication of plastids. Add a few drops of Benedict's solution to the slide and very carefully pass over a bunsen burner flame. Be extremely careful not to hold the slide over the flame for too long of a period (it may crack). Now examine slide under the microscope. Are there any changes evident in color of plastids? Why?

Testing for Sugar

Place a piece of raw apple in a test tube. Add 10 cc of Benedict's solution and heat slowly over the bunsen burner. What is the color change that indicates sugar is present as an organic nutrient?

Test the following foods in the same manner described above: potato, bread, grape, banana, meat, white of an egg, and others.

Testing for Starch

Place a piece of bread in a test tube. Add about 10 cc of water. Add a dilute solution of iodine. What is the color indicator for starch?

Test the following foods in the same manner described above: potato, bread, grape, banana, meat, white of an egg, soda cracker, others.

Testing for Protein

Place a small portion of hard-boiled egg white in a test tube with about 10 cc of water. Add about 10 drops of Biuret Reagent. What is the color indicator for protein?

Test the following foods in the same manner described above: potato, bread, grape, banana, meat, soda cracker, cheese.

In order to be able to distinguish color changes prepare a test tube with about 10 cc of water and 10 drops of Biuret Reagent and keep it close by for comparison.

Testing for Fat

Rub some butter on a piece of unglazed paper. What is the indicator for fat? (Ether may be mixed with food sample and then poured out on a piece of paper).

COLLOIDAL SUSPENSIONS

PURPOSE

To understand the sol-gel nature of protoplasm

ACTIVITY MATERIALS

Sodium chloride
Fine clay
Fine sand
Sausage casing
Glass tubing
Powdered gelatin

WHAT TO DO

Dissolve 3 g of powdered gelatin in 250 ml of warm water and stir until completely dissolved and distributed

Add 15 g of NaCl to 500 ml of water. Stir until all salt is completely dissolved

Stir in 3 g of fine clay into 250 ml of water. Set aside until later in an undisturbed area

Stir in 3 g of extra fine sand into 250 ml of water. Mix

Pass a strong light beam through each container except the clay mixture. How does the liquid appear? (milky, cloudy, or sparkly)

Place a small amount of each liquid in a separate "osmosis set-up" using sausage casing as the semipermeable membrane. Allow each "set-up" to remain immersed in a beaker of water for 20 minutes. Remove a 5 ml of water from each beaker and test each sample for protein by adding 2 ml of concentrated HNO_3 (nitric acid). If protein is present, a yellow color will be indicated.

Test the surrounding water in each beaker with a silver nitrate solution. If sodium chloride has diffused through a precipitate will form (white), if not, no precipitate will form.

Filter a few millimeters of each sample through filter paper.

Determine whether particles of the suspensions have settled to the bottom of their container by placing each container on a piece of white paper.

Heat a few mm of each fluid to the boiling point and allow each to cool. Is there any evidence that any of these suspensions gel?

	Light Beam	Protein	Gel	Settling Effect	Osmosis	Type of System
Gelatin and Water						
NaCl and Water						
Fine Clay and Water						
Fine Sand and Water						

Observe under low-power of the microscope:

A solution of table salt, homogenized milk, suspension of starch in water, oil, water and soap suspension, fine sand and water.

Decide which of the categories each of the following will belong: true solution, unstable suspensions, stable suspension or colloid.

What is the difference between colloids and solutions? What kind of system is protoplasm? Is protoplasm able to move from the gel to the sol and sol to gel state? Would you expect colloids or suspensions to provide better surfaces for chemical reactions? Of what possible use to living cells is the ability to go from sol to gel state?

References:

Smith, Ella Thea. "Exploring Biology," Teacher's Manual, 5th Ed., New York: Harcourt, Brace and Co., pp. 65-66.

Adapted from Laboratory Manual, BSCS Blue Version, pp. 87-89.

ENZYMIC ACTIONS

PURPOSE

To broaden understandings about the functions of various enzymes in living tissues.

ACTIVITY MATERIALS

Hydrogen Peroxide (H_2O_2)
Beakers
Test tubes
Funnel
Bunsen burner
Various tissues (plant and animal)
Filter paper
Mortar and pestle
500 ml beakers
Starch agar
FAA solution
Corn grains
Plain agar
0.1 N NaOH
0.1 N HCl
Thermometer
Soda crackers
Watch glass
Benedict's solution
Iodine solution
Test tube racks
Starch solution
1 ml pipettes
10 ml graduated cylinder
Ice
Paraffin
Wax pencil

WHAT TO DO

Amylase:

Students chew bits of soda cracker and places chewed cracker into a funnel lined with filter paper. Add a small quantity of warm water and filter, collecting filtrate in a test tube. Students now test some of the filtrate for starch and for sugar. Place some of the filtrate in a test tube and add a few drops of iodine solution. Place some of the filtrate in a test tube and add a few drops of Benedict's solution and heat over bunsen burner. What are the results of the iodine test? What are the results of the Benedict's solution test?

One student salivates into a test tube (be sure that student doing this has not been chewing gum or eating candy). Student tests a small portion of the saliva for starch and for sugar by tests given above. What is the result of the iodine test? What is the result of the Benedict's solution test.

Amylase

Collect saliva in a test tube and place the test tube in a beaker of ice. Add some small fragments of soda crackers. Allow this mixture to stand for about 20 minutes. Test for sugar with Benedict's solution. What are the results?

Collect saliva in a test tube and boil saliva over a Bunsen burner. Now add a few small fragments of soda crackers and set test tube aside in test tube rack for about 10 minutes. Test for sugar with Benedict's solution. What are the results?

Collect about 1 ml of saliva in a test tube. Using a wax pencil number six test tubes with numbers 1 through 6. Fill each of the six test tubes with 9 ml of water. Fill test tube No. 1 with 1 ml of saliva, and mix it thoroughly with the 9 ml of water. The first test tube now has a 1:10 dilution. Pipette 1 ml of solution from test tube No. 1 to test tube No. 2 and mix thoroughly. Test tube No. 2 now has 1:100 dilution. Continue on with dilutions until all the test tubes are filled. Add 1 ml of a starch solution to each test tube. Mix thoroughly and place all six test tubes in a warm water bath for about 10 minutes. Make tests with iodine to show the presence of starch. Repeat in another 10-minute interval.

Follow the procedure outlined above with six test tubes, but instead of tests for starch make tests for the presence of sugar. Use Benedict's solution.

Prepare three starch agar plates and one plain agar plate, numbering the three agar plates 1, 2, and 3. Number the plain agar plate 4. Cut in half longitudinally four soaked corn grains which are in the process of germination. Take four cut halves of the corn grains and place them cut side down on the agar of plate 1. Take the other four halves and soak them in FAA solution for a few minutes; blot them and place cut side down on agar plate 2. Cover all plates and put them in a dark, warm place for two days.

After two days have elapsed, flood plates 3 and 4 with an iodine solution, pouring off any excess iodine. What happens?

Remove the corn grains from plates 1 and 2 and flood both plates with an iodine solution, pouring off any excess iodine. What happens? Explain the comparison of plates 3 and 4 in relation to their results. Explain the comparison of plates 1 and 2 in relation to their results. Which of the plates were considered to be the "control"? Why? Why weren't dry corn grains used in this experiment?

Preparation of Starch Agar

Mix 10 g of powdered starch and 10 g of agar in 980 ml of water. Prepare as you would on any preparation of agar.

Preparation of FAA

Ethyl alcohol (50%)	90 ml
Formalin (40% Formaldehyde)	5 ml
Glacial Acetic Acid	5 ml

or

Isopropyl alcohol (anhydrous)*	50 ml
Formalin	10 ml
Glacial Acetic Acid	5 ml
Water	50 ml

*Dilute 70 ml of Rubbing alcohol with 28 ml of water to substitute for isopropyl alcohol (anhydrous).

References:

Wald, George, et al. "26 Afternoons of Biology." Reading, Mass: Addison-Wesley, 1962. pp. 28-29.

Laboratory Manual, BSCS Green Version

CELLULAR RESPIRATION

PURPOSE

To understand that the hydrogen normally liberated during respiration is removed by enzymes, dehydrogenases.

ACTIVITY MATERIALS

Methylene blue solution
Test tube
Yeast suspension
Medicine dropper

WHAT TO DO

Pour a ½ cc of yeast suspension into a test tube and dilute this with distilled water until the tube is nearly full. Pour a few cc's of this suspension into another test tube, add an equal volume of glucose solution and shake gently. Prepare a test tube half full of diluted yeast suspension, freshly prepared. Add 0.05% methylene blue solution to this tube dropwise, until the mixture is light blue. Allow the tube to remain in a test tube rack for sometime undisturbed. What is beginning to happen in the bottom part of the yeast suspension? Make a record of your observations. After an effect is established, swirl the contents in the test tube and add 1 cc 10% formaldehyde to kill the yeast cells. Swirl the contents vigorously and set the test tube aside once more for an undisturbed period of time.What happens at the bottom of the mixture? Record your observations and give reasons for this.

TEACHER EXPLANATION

Methylene blue has the property of being able to combine with hydrogen and becoming colorless when this happens. When hydrogen is replaced with oxygen methylene blue color is restored. It is possible to use this color indicator as a hydrogen acceptor and at the same time to record the chemical action by the color change taking place. Hydrogen is normally liberated during cellular respiration and is eventually combined with oxygen. If oxygen is not made available to an organism, methylene blue then can be substituted as a hydrogen acceptor and if a color change occurs, it can be concluded from this that respiration has taken place. This test demonstrates the presence of dehydrogenases enzymes used in the removal of hydrogen from fuel.

From:
Weisz, Paul B. Laboratory Manual in Biology. Copyright 1955. McGraw-Hill Book, Inc. pp 88-89. Used by permission

PHOSPHOROLYSIS

PURPOSE

To understand the concept of reversability of an enzyme reaction

ACTIVITY MATERIALS

0.01 M glucose solution
0.01 M glucose-1-phosphate solution
0.2% M KH_2PO_4 solution
0.2% Starch solution
Raw potato
Waring blendor
0.01 N Sodium Fluoride
Test tubes
Hot water bath
Cheese cloth
Beakers
Iodine-Potassium iodide solution

WHAT TO DO

Mark 7 test tubes, numbering each with a wax pencil. Add the following to each:

Test Tube 1

3 ml of 0.01 glucose solution
/very small drop of 0.2% soluble starch
3 ml of unboiled enzyme preparation

Test Tube 2

3 ml of 0.01 M glucose-1-phosphate
3 ml of boiled extract

Test Tube 3

3 ml of 0.01 M glucose-1-phosphate
/very small drop of soluble starch
3 ml of unboiled enzyme preparation

Test Tube 4

3 ml of 0.01 M glucose-1-phosphate
/very small drop of 0.2% soluble starch
3 ml of unboiled enzyme preparation

Test Tube 5

3 ml of 0.01 M glucose-1-phosphate
1 ml of 0.2 M KH_2PO_4
3 ml of unboiled enzyme preparation
/very small drop of soluble starch

Test Tube 6

3 ml of 0.2% soluble starch
1 ml of 0.2 M KH_2PO_4
3 ml of unboiled enzyme preparation

Test Tube 7

3 ml of 0.2% starch
1 ml of 0.2 M KH_2PO_4
3 ml of boiled enzyme preparation

/Add a small drop of 0.2% solution of starch to test tubes marked 1, 3, 4, and 5. (There should be so little starch in these four tubes that the iodine test will be negative--check to see it is so).

Enzyme Preparation

Peel a small potato and cut it into small cubes. Place potato cubes in a Waring blendor and add 40 ml of 0.01 N Sodium Fluoride and grind for about 30 seconds.

Filter material in blendor through a double layer of cheesecloth into a beaker. Squeeze out as much of the liquid as you can. Centrifuge this suspension for 3 minutes. Pour off the liquid on top into a test tube (supernatant). This extract is the enzyme preparation. Test this extract with iodine solution to see if it is still negative (it should be). Transfer about 10 ml of this extract into a test tube and heat for about 5 minutes in a boiling water bath.

Add 3 ml of the extract to test tubes marked 1, 3, 4, 5, 6
Add 3 ml of the boiled extract to test tubes marked 2, and 7

Test each of these preparations with iodine solution at 3 minute intervals for 30 minutes. Record results and explain.

What was the purpose of each of the chemicals in the mixtures you prepared?

What was the reason for each mixture?

What would have happened to the enzyme had you left out the Sodium Fluoride?

TEACHER EXPLANATION

"the energies of the reactants and products are fairly evenly balanced: a glucose-phosphoric acid bond has very nearly the same energy as a glucose-glucose bond. Hence little energy is lost or need be added in going in either direction." The reaction caused by the enzyme phosphorylase is a truly reversible action, as can be detected in the above experiment. "In neutral solution and at room temperature the equilibrium lies somewhat over toward polysaccharide synthesis: the system tends to synthesize rather than degrade polysaccharides. This synthesis, however, can occur only if two conditions are realized: (1) It proceeds, not from glucose, but from glucose-1-phosphate. The organism must begin by spending considerable energy in forming the initial glucose-phosphoric acid bonds. (2) The synthesis requires the presence of some polysaccharide on which to build (primer). The reaction adds glucose units to the end of already existing polysaccharide chains. Phosphorylase reaction builds up and degrades only straight polysaccharide chains."

$$\text{Glucose-1-phosphate} + \text{"primer"} \xrightleftharpoons{\text{phosphorylase}} \text{"primer"} + \text{glucose} + H_3PO_4$$

Wald, George, et al. "26 Afternoons of Biology." Reading, Mass: Addison-Wesley, 1962. pp. 30-31. (Reprinted with permission of publisher.)

"HILL REACTION"

PURPOSE

To understand the concept of how light energy is needed to break up the water molecule during photolysis in the process of photosynthesis

ACTIVITY MATERIALS

Dye 2,6 dichlorophenolindophenol (see appendix)
Spinach leaves
*0.5-M sucrose solution (see appendix)
Cheesecloth
Waring blendor
Centrifuge

WHAT TO DO

To secure chloroplast suspension mix spinach leaves and 25 ml 0.5 M sucrose solution at 0° C for 30 seconds in a Waring blendor. Filter the suspension through cheesecloth (two layers of cloth). Place the filtrate in a centrifuge at 50 G for 10 minutes. Pour off the fluid (supernantant) and recentrifuge at 600 G for another 10 minutes. Discard the clear fluid (supernantant) and suspend the pellet at the bottom of the tube in 0.5 M sucrose solution. It is important to keep the chloroplasts at 0° C for they will deteriorate rapidly at higher temperatures.

In each of two test tubes mix the following:

2 ml of phosphate buffer 0.1 M, pH 6.5
2 ml of dye solution (2,6 dichlorophenolindophenol, 2.5×10^{-4} M)
0.1 ml of chloroplast suspension (2 drops) secured as directed above
6 ml of distilled water

Wrap one of the test tubes immediately in black paper or aluminum foil to protect it from the light, and expose the other test tube to a bright light for 10 minutes. Compare the results of the two test tubes. (Protect the test tube from bright light's heat by placing a glass tumbler filled with water between the light source and the reaction tube.)

---

*Put 0.5 M sucrose in refrigerator

In the experiment the use of dye 2,6 dichlorophenolindophenol will act as an artificial electron acceptor as TPN (coenzyme) in plants acts as a hydrogen acceptor in photolysis. The dye will be reduced during the course of the reaction by a loss of the blue color.

$$\text{Dye (blue)} + H_2O \xrightarrow[\text{chloroplasts}]{\text{light}} \text{Dye } H_2 \text{ (colorless)} + \tfrac{1}{2}O_2$$

Wald, George, et al. "26 Afternoons of Biology." Reading, Mass: Addison-Wesley, 1962. pp. 51-52. (Reprinted with permission of publisher.)

ABSORPTION OF LIGHT ENERGY

PURPOSE

To understand something about the absorption, reflection and composition of light in relation to photosynthesis

ACTIVITY MATERIALS

Prism
Source of light
Different colors of material
Thermometer
Cellophane of various colors
Chlorophyll extract

WHAT TO DO

Obtain chlorophyll extract as mentioned in laboratory exercise "Studying Green Pigments in Plants by Paper Chromatography" and place in a test tube rack.

Shine a beam of white light through a prism onto a screen
  a. Students mention the colors of the spectrum
  b. Give the number of colors that can be seen

Shine a bright light on a square of black cloth and a square of white cloth. Place a thermometer underneath each piece of cloth and after a 10 minute interval record the temperature of each. Is there a temperature differential? If so, can you relate the fact that absorption of light is highly related to what other factor? Would this affect the color of clothes worn during the summer and winter months? Why?

Shine a beam of light of various colors on a white surface. Use a sheet of red cellophane over the beam of light, then blue cellophane, green cellophane, and so on. Does the white surface change its color with the change of the colored light?

Shine a beam of light through the chlorophyll extract so that it is projected on the screen. What colors can be seen on the screen? What colors cannot be seen on the screen? What colors would a green leaf be able to transmit and what colors would it be able to absorb based on the observations just made?

Pass the red light (using red cellophane) through a prism and project it on a screen. What colors are found in the spectrum? Do this for various colors using cellophane. What colors are found in each of the spectra?

Laboratory Manual, BSCS Yellow Version, pp. 435-436.

STUDYING GREEN PIGMENTS IN PLANTS BY PAPER CHROMATOGRAPHY

PURPOSE

Learning about the component parts of green pigment in plants by separation technique on paper

ACTIVITY MATERIALS

Sand
Mortar and pestle
Spinach leaves (or other green leaves, such as Virginia Creeper)
Acetone
Whatman paper #1 (roll of 1½ inch)
Test tubes
Cork stoppers
Paper clips
Petroleum ether
Source of light

WHAT TO DO

Preparation of Chlorophyll Extract:

Teacher prepares extract of green pigment to be used in this laboratory exercise:

> Grind or mascerate about 20 g of spinach leaves with about 50 ml of acetone in a mortar (which contains some fine sand). Line a glass funnel with cheesecloth and cleansing tissue and pour liquid through to be filtered. Collect filtrate in a large test tube and shine a beam of light through the filtrate. Ask students to notice what happens? What is one of the characteristics of this extract? Of what benefit is this fluorescent quality in a green leaf? Inspect chlorophyll extract through a spectroscope. What is the absorption spectrum?

Preparation of the Chromatogram

Student prepares a strip of Whatman #1 paper so that it is just long enough to fit test tube. The paper should not touch the bottom of the tube when it is lowered on hook extending from cork. Unbend a paper clip, so that it is shaped like a letter "J." Insert the long part of this wire into a cork stopper that will fit the test tube. Hook the thin strip of Whatman paper onto this hook.

Draw a light pencil line about 2 cm from the tip of the strip of paper and with a very fine pipette streak (or leave a small dot) with green extract. Allow this to dry and restreak with extract. Lower this strip of paper into a test tube which contains a solvent mixture of petroleum ether (92%) and acetone (8%). (Other mixtures are suggested in references listed at end of this exercise). Allow the strip of paper to be dipped into the solvent mixture and stopper the test tube. Check the movement of the solvent noting the time it takes for the "solvent front" to reach the top of the paper. Record those colors that appear first, second, and so on. (See figure 1).

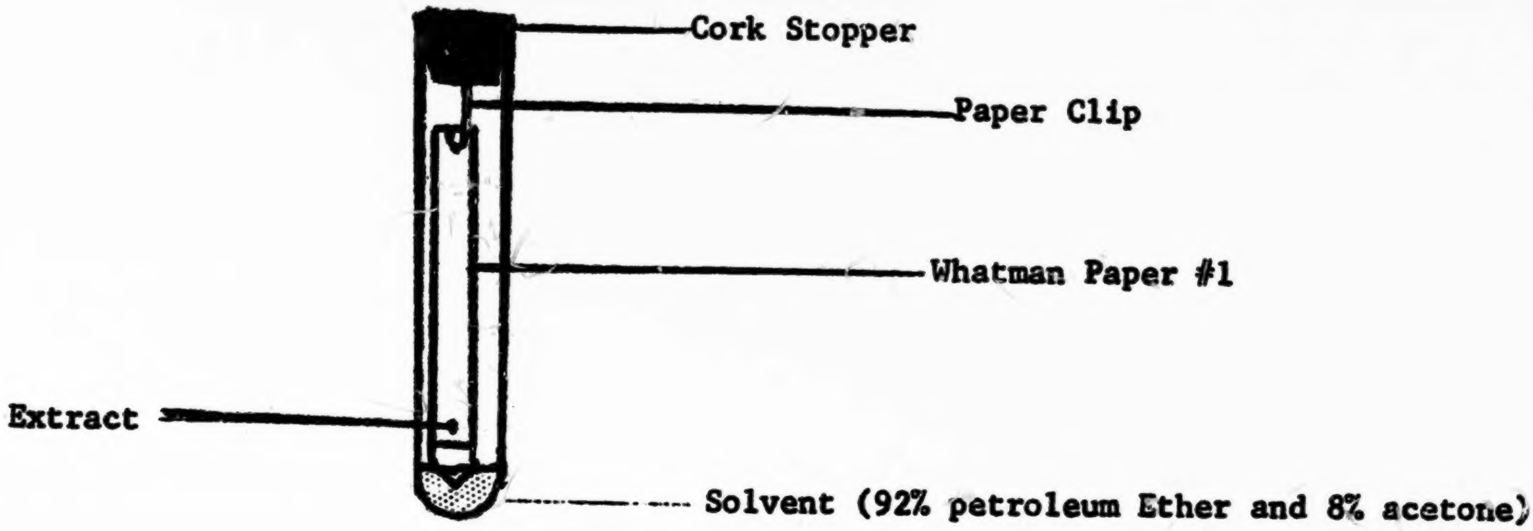


Figure I

Remove the strip of Whatman paper from test tube after the "solvent front" has reached the top of the strip (near the hook). Allow the paper to dry. Try to identify the main areas of color and outline them lightly in pencil. Attach your chromatogram to a sheet of notebook paper and label as many of the areas as you can. The pigments can be identified tentatively by means of their general color and their position on the paper.

Analysis

List the colored bands starting from the top of the chromatogram and working toward the tip. Are the colors of the bands different? Is chlorophyll composed of a green pigment only? What are the two major colors in your chromatogram?

NOTE TO THE TEACHER

Fast moving band of carotenes will have an R_f of 1.00. Lower on the paper strip starting at about R_f 0.4, there will be 1 or 2 yellow bands of xanthophylls bluish-green chlorophyll a and yellowish-green chlorophyll b. Above the xanthophylls may be a gray band of pheophytin, a chlorophyll breakdown product.

Determine the absorption spectra of chlorophyll a and chlorophyll b by first cutting out the two chlorophyll bands on your chromatogram. Remove the bands by leaching the pigments in small test tube of a few ml of acetone. Remove the filter paper with forceps and observe the absorption of these two solutions at the specified wave lengths in the hand spectroscope or measure it in a spectrophotometer. Which pigment migrated faster on your chromatogram? What is the chemical difference between chlorophyll a and b. Why is chlorophyll green?

Chlorophyll a has a major absorption band at about 680 m and chlorophyll b has an absorption band at about 665 m

R_f is the distance that any substance moves in relation to the solvent front

$$R_f = \frac{\text{distance substance moves}}{\text{distance the solvent moves}}$$

Thus, if the solvent front moves 5 cm and the substance analyzed moved 2.5 cm, the R_f of the latter is

$$R_f = \frac{2.5\text{ cm}}{5\text{ cm}} = 0.5\text{ cm}$$

Chromatography is a technique for the separation of chemical substances from a mixture. The technique is simple and can be used in the classroom. The mixture to be analyzed is placed in a spot on one end of the filter paper. This is dried. Then the end of the paper is dipped into a solvent. As the solvent works its way up the filter paper, the chemical substances in the mixture also moves up. The total distance each component chemical mixture moves in a particular solvent depends on its own inherent properties. Some molecules move a short distance while others move further. This is the basis for separation.

References for the Teacher

Block, R. J., E. L. Durrum, and G. Zweig. Manual of Paper Chromatography and Paper Electrophoresis, 2nd Edition. Academic Press, 1958.

Gray, G. W. "Electrophoresis," Scientific American, 185, No. 6 (Dec., 1951) pp. 45-53.

Stein, W. H., and S. Moore. "Chromatography," Scientific American, 184, No. 3 (March, 1951) pp. 35-41.

Weier, Botany, A Laboratory Manual. 1957.

Lind, Lane, and Gleason. "Partial Separation of the Plastid Pigments by Paper Chromatography," Plant Physiology, 28:325, 1953.

PURPLE SULFUR BACTERIA - BACTERIAL PHOTOSYNTHESIS

PURPOSE

To demonstrate that certain bacteria (purple sulfur bacteria) can secure their energy through photosynthesis

ACTIVITY MATERIALS

Sodium Bicarbonate
Ammonium sulfide
Ammonium chloride
Dibasic potassium phosphate
Magnesium chloride
Fresh mud
Container with ground glass stopper
Slide and cover slips
Microscope
Illumination source

WHAT TO DO

Prepare a mineral solution containing 0.5% sodium bicarbonate, 0.1% ammonium chloride, 0.02% magnesium chloride, 0.5% dibasic potassium phosphate, ammonium sulfide -9 H_2O-0.1%. Fill bottle with this medium and add a small amount of fresh mud from a river bottom or other area where active organic decomposition is in progress. Place under continuous illumination from a lamp at room temperature for 7-10 days. Formation of purple pigment indicates growth of the purple sulfur bacteria. Examine microscopically to determine the presence of sulfur granules. Discuss the role of these bacteria in mineral cycles.

Adapted from "Suggestions for Experiments in Bacteriology," The American Biology Teacher, Volume 22, No. 6 (June, 1960), p. 380.

LIGHT AND PHOTOSYNTHESIS

PURPOSE

To demonstrate that the intensity of a light source will limit the rate of photosynthesis

ACTIVITY MATERIALS

Elodea sprigs
1% Sodium bicarbonate solution
Test tubes
"Volumeter set-up" (Mason jar, 2 test tubes, 2 pinch clamps, 2 1 ml pipettes,
2 rubber stoppers with 2-hole)
Light source 60-100 watt lamp

WHAT TO DO

Prepare the following set-up as shown in figure 1. (Volumeter is a device that measures gas exchanges in terms of changes in the total volume of gas at constant pressure.)

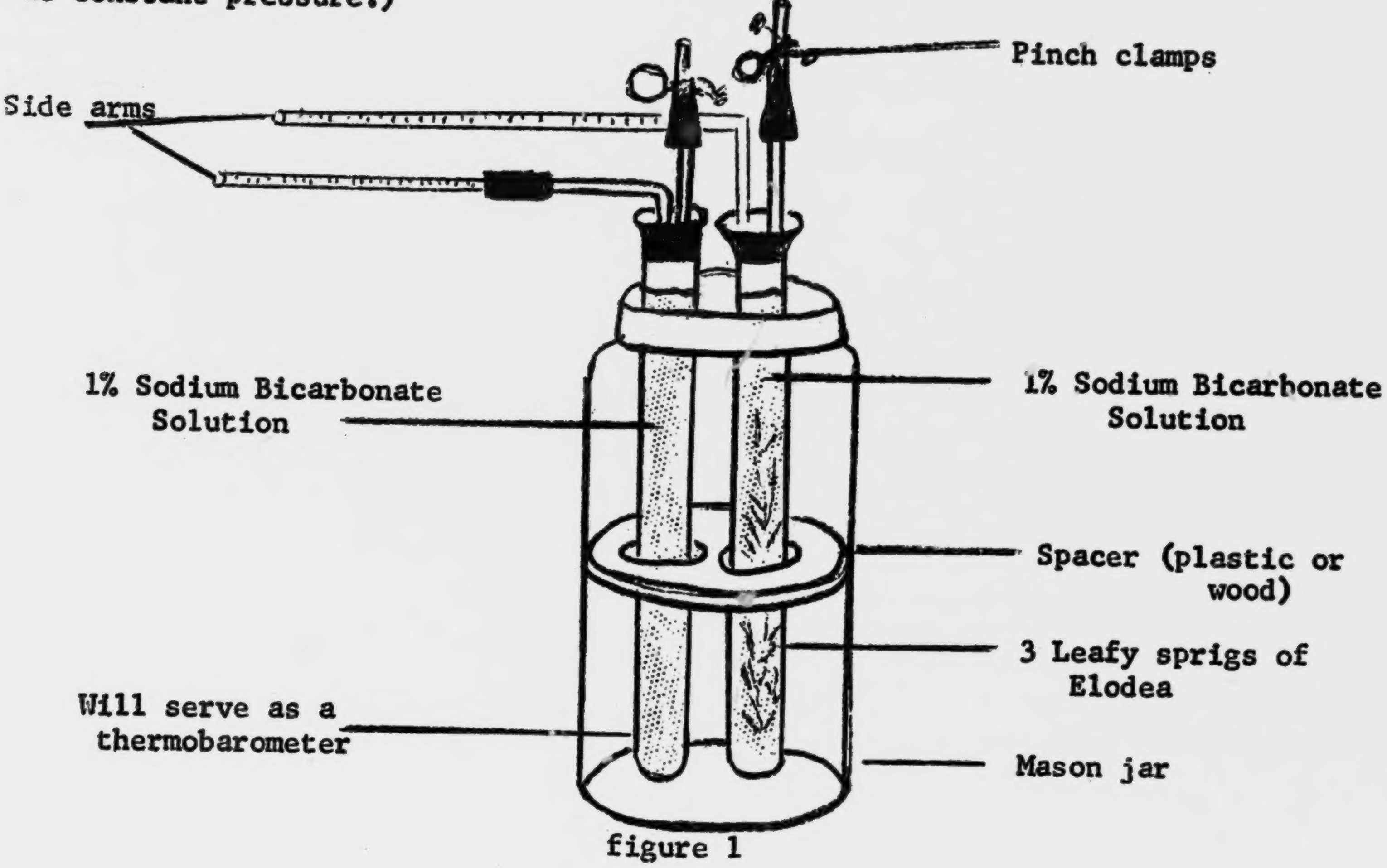

Pinch clamps
Side arms
1% Sodium Bicarbonate Solution
1% Sodium Bicarbonate Solution
Spacer (plastic or wood)
3 Leafy sprigs of Elodea
Will serve as a thermobarometer
Mason jar

figure 1

Place three leafy sprigs of Elodea in one of the test tubes of the Volumeter and fill this test tube with a 1% solution of sodium bicarbonate solution. Leave about 3 to 6 mm between the liquid surface and the stopper. Fill second test tube with an equal amount of 1% sodium bicarbonate solution to serve as a thermobarometer.

Use a 60-100 watt goose neck student lamp as a light source. Place a receptacle filled with water between the light source and the volumeter to keep the heat radiations of the lamp from distorting the readings. Place the lamp as close as possible, always keeping the heat filter between. Draw a drop of kerosene into the proximal end of each side-arm 1 ml tube and close the pinch clamps. Allow the system to operate for about 5 to 10 minutes. This equilibration time is needed to saturate the water with the oxygen that is being evolved; thereafter all gas produced is given off. Release the clamps and take readings in both side-arms at 2 minute intervals, each time subtracting the reading in the thermobarometer from that in the experimental tube. Go on with the readings until the rate of change remains constant through 3 consecutive readings.

After the rate has stabilized, move the light source twice the distance from the plant, and after taking readings at this distance, double the distance once again.

Plot your readings on a graph showing the distance and the variation in the process. What conclusions can you gain from this experiment? What effect does light intensity have on O_2 evolution?

*Have students report on the inverse-square law.

Wald, George, Peter Albersheim, John Dowling, Johns Hopkins, III, and Sanford Lacks. "26 Afternoons of Biology." Reading, Mass.: Addison-Wesley, 1962. p. 52 and p. 35. (Reprinted with permission of publisher.)

*Joseph, Brandwein, Morholt, Pollock, Castka. A Sourcebook for Physical Sciences. New York: Harcourt and Brace, 1961. p. 479.

PHOTOSYNTHESIS

PURPOSE

To demonstrate factors necessary in the process of photosynthesis

ACTIVITY MATERIALS

Aluminum foil or black paper
Potted geranium plants
Alcohol
Beakers
Hot plate
Dilute iodine solution
Vaseline
Elodea sprigs
Funnel
Test tube

WHAT TO DO

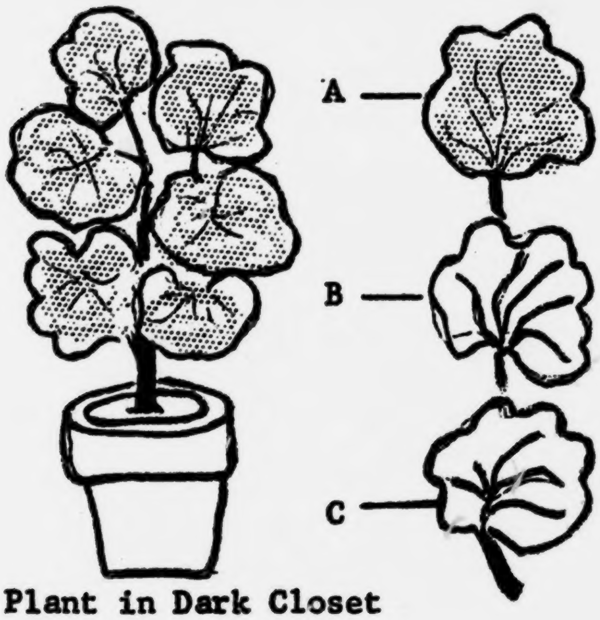
Necessity of Light in Starch Manufacture

Place a green plant in a dark place for 2 or 3 days. Place another plant in sunlight for a day or so. Cover the part of one leaf of the plant that remains in sunlight with aluminum foil or black paper.

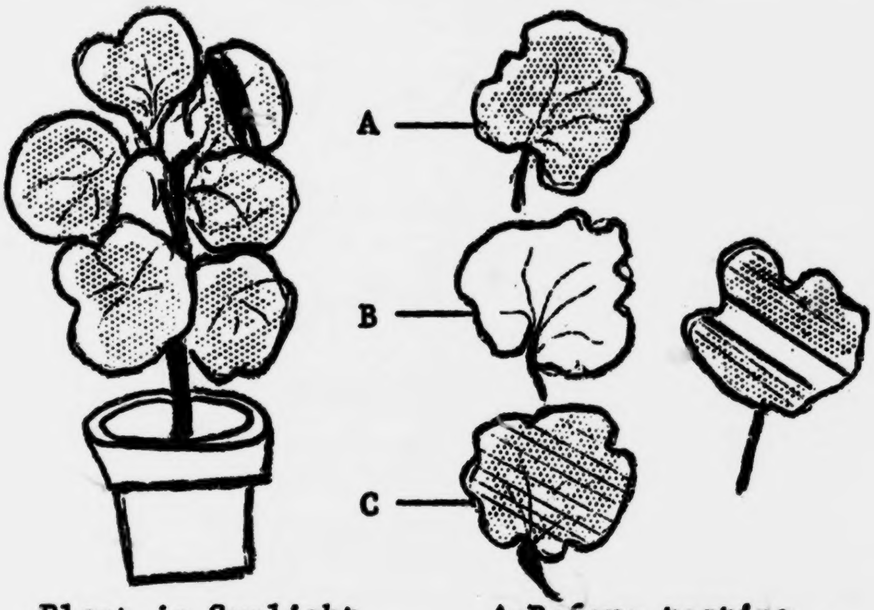
Remove a leaf from the plant that has been kept in darkness and test for starch. Heat some water in a beaker to the boiling point. Drop the leaf into the hot water for 2 or 3 minutes. Transfer the leaf to grain alcohol. Boil the leaf in alcohol (use a hot water bath). Note the disappearance of chlorophyll from the leaf tissues. When the leaf is white, dip it in cool water to rinse off the alcohol. Spread leaf out on a petri plate and flood with iodine solution. What is the color indicator for this test? Is starch present in the leaf that has been in darkness?

Remove a leaf from the plant that has been in the sunlight. Follow procedure given above to remove chlorophyll. Place in a petri plate and flood with iodine solution. What are the results of this test?

Remove the partially covered leaf and remove chlorophyll as explained above. Test for starch. What are the results? Why do some parts show blue-black color and other parts of the same leaf do not?



Plant in Dark Closet
for 2 or 3 days



Plant in Sunlight
for 48 hours

A-Before testing
B-Green color removed
C-Iodine testing

Make a sketch of a coleus leaf showing the colors, such as red, green, yellow, and purple. Prepare a variegated coleus leaf in the same manner as described on preceding page. When variegated coleus leaf with its yellow, purple, red, and green areas is placed in hot water, the red and purple pigments are dissolved out. The purple pigment masks the chlorophyll, but the yellow and red areas show that chlorophyll is not present. After the chlorophyll has been removed and iodine solution is applied. Which areas indicate the presence of starch? green, purple, yellow, or red?

Carbon Dioxide is Necessary for Photosynthesis

Place a potted plant, such as a geranium, in a dark place for several days. Cover one-half of the lower surface of one to several leaves on the plant with vaseline. Place the plant in sunlight for several hours. After the leaves have been exposed to light, remove one of the treated leaves and boil in water for several seconds. Remove from boiling water and place in alcohol as described on preceding page. After all chlorophyll has been removed, test for starch. Does the presence of starch show on the side of the vaseline cover or on the side without the vaseline cover? Why?

References:

Miller, and Blaydes. Methods and Materials for Teaching Biological Sciences. New York: McGraw-Hill, 1938. pp. 304-305 and 958.

Morholt, Brandwein, and Joseph. A Sourcebook for the Biological Sciences. New York: Harcourt and Brace, 1958. p. 16 and p. 18.

BIOLOGY 1

RESOURCE UNIT

UNIT TWO: VARIETY OF LIFE

LOS ANGELES CITY SCHOOLS
Curriculum Branch
1963

ACKNOWLEDGMENTS

The Curriculum Branch wishes to express appreciation to the teachers and students who used experimentally the teaching suggestions and activities outlined in the resource units for Biology 1.

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MARY LOUISE JONES
Secondary Curriculum Coordinator

AVERILL M. CHAPMAN
Administrator of Curriculum

UNIT TWO: VARIETY OF LIFE

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UNIT TWO: VARIETY OF LIFE

USE OF THE RESOURCE UNIT

This resource unit has been prepared and developed for use by biology teachers in Los Angeles City Schools. It is intended that this resource unit be filed in a three-hole loose leaf binder by the teacher. It is hoped that this unbound material will be of greater use to the teacher and will be more adaptable to making changes in sequence and providing for additions and deletions.

The Outline Course of Study for Biology 1, publication SC 597 contains general information vital to the teaching program and should be referred to often. General safety regulations, teaching patterns, and point of view are some of the important sections of this publication. The teacher will find it helpful to use both the Outline Course of Study and the Resource Unit. The Outline Course of Study is available from the Curriculum Branch.

How To Use The Resource Unit

Outline of Content

The teacher should briefly review the pages of this section to receive an over-all view of the entire unit content.

Estimated Time Block

After reviewing the outline of content for this unit, the teacher should make note of the suggested time allotment. The teacher should be encouraged to prepare a block of squares showing the four, five or six week period and plan his own pattern of time allotment for subject matter. The teacher need follow only the estimated time block.

Concepts to Consider

Read the concepts to consider at the beginning of this unit. These concepts are major generalizations of subject content and should serve as guidelines for instruction.

Teaching Approach (Methods and Activities)

The teacher will find this section to be a suggested direction or path for instruction. The approach is sequential and may be used at the discretion of the teacher. It will be noted that there are many more suggestions for teaching than can be carried out for a particular time block. The teacher is charged with the responsibility of selecting those activities best suited to the ability level of his students.

Depth Probe

This section provides three general levels of ability for slow students, average students, and more able students. The teacher may use any or all of these activities. An attempt has been made to alert the teacher to activities that are basic to the subject content. Note that terms such as "optional" or "basic" have been used in this respect. All activities to be done will be decided upon by the individual teacher according to materials and student abilities irregardless of established color code.

"Tools" for Extending Concepts

This section is intended to supply the teacher with enrichment ideas for highly motivated students. Remember that many more ideas have been given than can possibly be carried on, so select those activities that are most suitable.

Planning Ahead

This section is intended to alert the teacher to materials needed for activities coming in following sections of this unit and other units. Pay particular attention to this section on ordering materials from the Science Center, since a two-week-in-advance-order is necessary for many of the fresh materials.

Broadening "Content Horizons"

This section is divided into three parts. The first part is an area devoted to references to be used by the teacher to gain a broader background for subject content. The second part is an area devoted to references to be used for students and care has been taken in recommending those books that are generally found in school libraries. The third part is an area devoted to the textbook reading assignments for the particular subject content. The two textbooks cited are Smith, Ella Thea Exploring Biology 4th and 5th Editions; and Moon, Otto, and Towle Modern Biology, 1960 and 1963 Editions.

UNIT TWO: VARIETY OF LIFE

CONTENT OUTLINE

I. Basis for Organization

- A. Resemblance (Homology)
- B. Homoplasy (Analogy)

II. Organization of Living Things

- A. Nomenclature and Taxonomy (Linnaeus and Others)
- B. The System (A Sample Classification)
- C. Overview of Plant and Animal Classification

III. Variety in Animals

- A. Basic Animal Characteristics
- B. Multicellularity
  - 1. Lower Forms of Animal Life
    - a. Porifera
    - b. Coelenterates
    - c. Worms
  - 2. More Complex Forms of Animal Life
    - a. Mollusks
    - b. Echinoderms
    - c. Arthropods
    - d. Vertebrates
- C. Evolutionary Patterns and Comparative Significance

IV. Variety in Plants

- A. Basic Plant Characteristics
- B. Lower Forms of Plant Life
- C. More Complex Plants
    - 1. Mosses and Liverworts
    - 2. Vascular Systems (Conditions for Land Life)
    - 3. Vascular Plants
        - a. Ferns
        - b. Horsetails
        - c. Club Mosses
        - d. Seed Plants
            - (1) Cone
            - (2) Flower
- D. Evolutionary Patterns and Comparative Significance

UNIT TWO: VARIETY OF LIFE

TEXTBOOK REFERENCE SUMMARY

Smith, Ella Thea

Exploring Biology 4th Edition

Basis for Organization	pp. 48-56
Variety in Animals	pp. 73-125 and 154-173
Variety in Plants	pp. 56-71 and 128-152

Exploring Biology 5th Edition

Basis for Organization	pp. 102-107
Variety in Animals	pp. 158-261 and 295-327
Variety in Plants	pp. 82-90 and 102-151

Moon, Otto, and Towle

Modern Biology 1960 Edition

Basis for Organization	pp. 77-87
Variety in Animals	pp. 229-414
Variety in Plants	pp. 91-145

Modern Biology 1963 Edition

Basis for Organization	pp. 77-88
Variety in Animals	pp. 229-416
Variety in Plants	pp. 91-144

UNIT TWO: VARIETY OF LIFE

MASTER MATERIALS LIST

EQUIPMENT

- Microscopes
- Stereomicroscopes
- Skeletons, bird, rat, frog, fish

SUPPLIES

Non-Consumable

- Bell jars
- Flannel boards
- Pans, Enamel
- Scalpels
- Scissors
- Tripod lenses

Consumable

- Glassware
  - Pipettes (eye dropper type)
  - Syracuse glasses
  - Watch glasses

- Chemicals
  - Brom thymol blue powder

- Other Materials
  - Bacteria, prepared slides
  - Bean and Corn seeds
  - Birds (loan exhibits)
  - Camel's hair brushes
  - Centipede (preserved specimens)
  - Celluloid sheets
  - Clay, modeling
  - Construction paper (various colors)
  - Crayolas
  - Dissecting needles
  - Flocking paper backing
  - Flashlight
  - Flowers (varieties of several freshly picked)
  - Forceps, curved and straight points
  - Fruits (a variety freshly picked)
  - Grasshoppers (preserved specimens)
  - Jellyfish (preserved specimens)
  - Liver, raw
  - Lichen (dried or fresh specimens)
  - Millipede (preserved specimens)
  - Mold, bread (prepared slides or living specimens)
  - Moth (preserved specimens or living)
  - Nuts, bolts, and screws
  - Pine (leaves and cones--preserved or living)
  - Rulers, transparent mm.
  - Razor blades
  - Spider (preserved or living specimens)
  - Starfish (dried or living specimens)

LIVING AND FRESH MATERIALS

- Ameba culture
- Algae, red, brown, and green
- Cactus, potted
- Crayfish
- Euglena culture
- Earthworms
- Fern (potted or living leaves)
- Frogs (living and preserved)
- Fish
- Hydra, green and brown
- Liverworts
- Mimosa plants (potted)
- Nematodes (microworms)
- Oysters or clams
- Paramecium culture
- Planaria
- Rotifer culture
- Rat (living or preserved)
- Snails
- Spirogyra (living or prepared slides)
- Slime molds
- Sponges (preserved fresh-water or dried specimens of marine types)
- Salamanders

UNIT TWO: VARIETY OF LIFE

ESTIMATED TEACHING TIME: 3 WEEKS

Suggested allotment of time in block below:

Monday	Tuesday	Wednesday	Thursday	Friday	Week
Basis for Organization	(Nomenclature) Organization of Living Things	Organization of Living Things	Basic Animal Characteristics Lower Forms	Lower Forms of Animals	1st
Lower Forms of Animals	Complex Forms of Animals	Complex Forms of Animals (Evolutionary Significances)	Complex Forms of Animals (Evolutionary Significances	Optional	2nd
Basic Plant Characteristics Lower Plant Forms	Lower Plant Forms More Complex Plant Forms	Complex Plant Forms (Evolutionary Significances)	Complex Plant Forms (Evolutionary Significances	Optional Test	3rd

UNIT TWO: VARIETY OF LIFE

CONCEPTS TO CONSIDER

Any two or more living things are related if they have homologous structures.

Homologous structures are structures that are similar and are located in corresponding parts of organisms' bodies.

Organisms having the same anatomical pattern do belong to the same biologically evolving population.

Members of a species can interbreed and produce fertile offspring.

A species is a group of individuals of historically recent common descent, suited to the same environment and manner of living, and capable of reproducing among themselves offspring with these same characteristics.

All living things, plants and animals alike, are related by ascent from common origin, from which they evolved along separate paths to their state of divergence.

Classification is an arbitrary method of placing living organisms into orderly groups which are based on structural characteristics.

Latin is the basic language of taxonomy.

The basic taxonomic unit is the species.

Carl von Linné (Linnaeus) introduced a system of naming and classification.

The members of each kingdom are arranged in a hierarchy of groupings.

The major groups of each kingdom are phyla; from these are broken down into smaller and smaller divisions, finally to category where the organism is given a double name, genus, and species.

Phyla are large groups based on radically different plans of organization.

Members of a class grouping within a phylum are on the basis of a significant variation in the fundamental plan.

TEACHING APPROACH (Methods and Activities)

Discuss the concept of the great variety of living things. Give figures on the different numbers of insects, and other types of animals and plants.

- Number and label a variety of plant and animal specimens and place them around the room. Ask students to make observations in order to decide whether the specimen is a plant or animal and in order to reach other pertinent conclusions about the specimen. See p. 141.
- Bring out the concept that living things can be classified together into large groups because of certain important similarities. Ask students to list some of these similarities.

Discuss the importance of homology vs. analogy in understanding similarity of structure in living things.

- Ask students to label diagram showing homologous structures of various animal appendages. See pp. 142-143.
- Ask students to make sketches of some structures that show analogous resemblances.
- Display skulls, teeth, and bones of various animals to help point up homology.

Discuss the concept of classification.

- Introduce the idea of classification through a flannel board demonstration suggested on p. 144.
- Read about Carl von Linné, Buffon, Darwin, LaMarck, and others and their influence on the concept of classification.
- Ask students to make comparisons of living specimens to learn more about classification.
- Have several students describe a horse, dog, cat, or other organisms without naming it. Ask them to make the description of each animal fit only that particular organism and no other.
- Discuss the binomial system of nomenclature.
- Discuss the new emphasis on a more "natural" classification system.
- Demonstrate the use of the hierarchy of classification by using an example, such as:

    ORGANISMS: Everything that is alive, including daisy, earthworm, fish, frog, cat, gray squirrel, and red squirrel.
    ANIMALS: No daisies, but including earthworm, fish, frog, cat, gray squirrel, and red squirrel.
    VERTEBRATES: No earthworms, but including fish, frog, cat, gray squirrel, and red squirrel.
    TETRAPODS: (four-limbed vertebrates) No fishes, but including frog, cat, gray squirrel, and red squirrel.
    MAMMALS: No frogs, but including cat, gray squirrel, and red squirrel.
    RODENTS: No cats, but including all kinds of squirrels (also rats, porcupines, etc.).
    SQUIRRELS: Divided into red and gray squirrels, among others.*

- Introduce students to the concept of a "key" in classification.
- Students prepare a dichotomous key of their own making. See p. 149.
- Prepare an over-all view of the NEW classification of the plant and animal kingdom for all students.

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*Simpson, et al., Life: An Introduction to Biology. (New York: Harcourt, Brace, and World, 1957), p. 460.

UNIT TWO: VARIETY OF LIFE

DEPTH PROBE

- VARIETIES OF LIVING THINGS, p. 141 (Average Student Basic Activity)--Allows the student to make observations about living things and to become aware of the variety of living things. Students work individually.

- HOMOLOGY AND ANALOGY, pp. 142-143 (Average Student Basic Activity)--Helps the student understand the concept of homologous structures as one basis for organization. Students work in groups or in pairs.

- AN INTRODUCTION TO CLASSIFICATION, p. 144 (Average Student Basic Activity)--A flannel board exercise demonstrating the concept of classification. Teacher demonstration.

- MAKING COMPARISONS IN LIVING THINGS, p. 145 (Average Student Basic Activity--Optional)--Aids the student in making comparisons of living things on the basis of structural appearances. Students work in groups.

- MAKING A DICHOTOMOUS KEY, p. 149 (More Able Student Basic Activity)--Learning the mechanisms of a "key" in classification. Students work individually.

"TOOLS" FOR EXTENDING CONCEPTS

- Plan to show filmstrip, "Carolus Linnaeus" (See Blue Box Collection in your Science Department.)
- Plan to show film, "Characteristics of Plants and Animals," Fsd 547.1-2.
- Assign students to make reports on Linnaeus, Darwin, Buffon, LaMarck, and others.
- Prepare a bulletin board display entitled VARIETY IS THE SPICE OF LIFE to portray the many kinds of living things.
- Prepare a bulletin board display entitled HOMOLOGUES AND THEIR ANALOGUES, making comparisons of homologous structures in various living organisms and their analogues through similar function.
- Assign students homework on finding characteristics about plants and animals, their differences and similarities.
- Assign students the classification of a dog, cat, horse, rose, and man.

- Encourage students to prepare other dichotomous keys for plants or animals.
- Assign students various descriptive words used in binomial nomenclature to find their meanings and to give descriptions on how they are used in the name, i.e., alba, domestica, ponderosa, and others.
- Encourage some students to make a collection of fresh-water algae, sea shells pine cones, starfish, and others. Students will learn to classify and identify specimens in their own collection.
- Students make a list of plants and animals in Southern California that have more than one common name.
- Students write a paragraph on why common names of living organisms are confusing.
- Encourage students to collect pictures of plants and animals and to classify their pictures.

PLANNING AHEAD

- Collect and store a variety of dry sponges.
- Check ongoing protozoan culture.
- Order Hydra and Planaria, if this has not already been done.
- Assign students to help collect living earthworms for use in experiment on page 161.
- Order living frogs and locate preserved specimens of grasshoppers, frogs, and crayfish.
- Locate and reserve prepared slides of hydra, cross sections of sponge and others.
- Encourage students to bring their rats, mice, or hamsters to school for experiment on page 169.
- Locate and reserve skeletons of frog, rat, or other vertebrates.
- Prepare ditto sheets with necessary information needed in exercises on pages 156-170.
- Encourage a student team to prepare a bulletin board showing comparisons of animals being studied at the time. Use titles such as Frog and Rat, Ascaris and Earthworm, and so on.
- Assign some students the task of making paper skeletons of a frog and a rat.
- Check the school library for text and reference materials on structure and function of animals in the next section starting on page 150.

UNIT TWO: VARIETY OF LIFE

BROADENING "CONTENT HORIZONS"

Teacher References:

Simpson, G., et al. Life: An Introduction to Biology. New York: Harcourt-Brace, 1957. (Title III - Collection)

Villee, Claude. Biology, 4th Edition. Philadelphia, Pa.: Saunders, 1962.

Mayr, E., E. B. Lindsley, and R. L. Usinger. Methods and Principles of Systematic Zoology. New York: McGraw-Hill, 1953.

Morgan, A. Fieldbook of Animals in the Winter. New York: Putnam's Sons

Morgan, A. Fieldbook of Ponds and Streams. New York: Putnam's Sons, 1930.

Student References:

Burnett, W. H. Zim, and H. Fisher. Golden Science Guide to Zoology. New York: Golden Press, 1958.

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Klotz, A., and E. Klotz. Living Insects of the World. Garden City, New York: Doubleday

Schmidt, K. P., and R. F. Inger. Living Reptiles of the World. Garden City, New York: Doubleday

UNIT TWO: VARIETY OF LIFE

Textbook References:

- Moon, Otto, and Towle. Modern Biology. pp. 77-88
- Smith, Ella Thea. Exploring Biology, 5th Edition. pp. 102-107

VARIETIES OF LIVING THINGS

PURPOSE

Learning to make observations about living things (preserved or otherwise)

ACTIVITY MATERIALS

Living or preserved specimens of:

Euglena
Paramecium
Amoeba
Bacteria
Nematode
Red algae
Fern
Pine
Yeast
Cactus
Mollusk
Centipede
Sensitive plant
Millipede
Bird
Mushroom
Spider
Hydra
Earthworm
Rotifer
Volvox
Green algae
Slime mold
Frog
Lichen
Bread mold
Fish
Reptile
Kelp
Sponge
Morel
Planaria
Liverwort
Rat
Luna Moth
Jellyfish
Crayfish

WHAT TO DO

Place a specimen at each desk with a number and label attached to it. Students move at a given signal from one specimen to another always moving to the next higher number.

If the specimen is a plant the student will indicate P. If the specimen is an animal the student will indicate A. If the student is not sure about the category use a symbol U for undecided. Fill the chart shown below for each observation of a specimen.

A P or U	Color or Size	Check (✓) only if present			Legs	Jointed Body	Any Other Characteristics
		Stem-Roots	Backbone	Flower Seeds			

HOMOLOGY AND ANALOGY

PURPOSE

To understand the concept of homology as a basis for organization of living things

ACTIVITY MATERIALS

Drawings of various skeletal structures or
Bones of the arm or leg of various animals

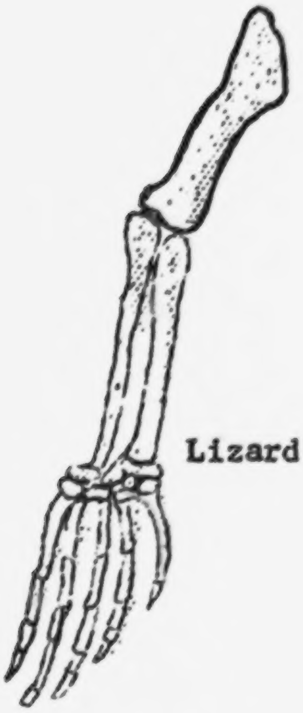
WHAT TO DO

Students make a comparison between the bones in the arm of man to the bones in the frog, whale, lizard, bird, cat, and bat

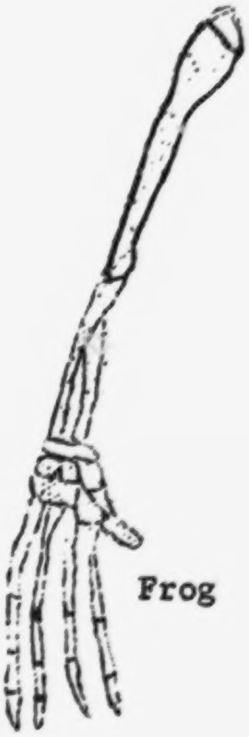
Students label by use of their own key those structures that are exactly the same (perhaps the use of colored pencils) to show homologous structures.

Students prepare sketches of analogous structures for the above animals

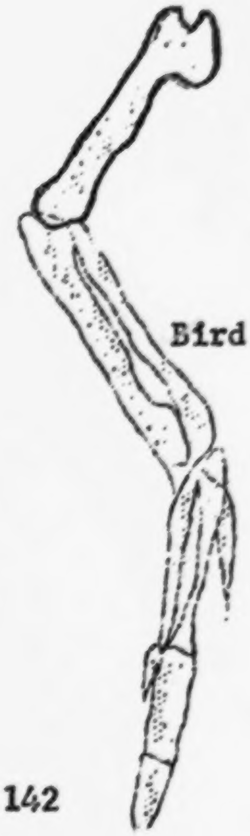
What is the difference between homologous and analogous?
How can homologous structures be used in classification?



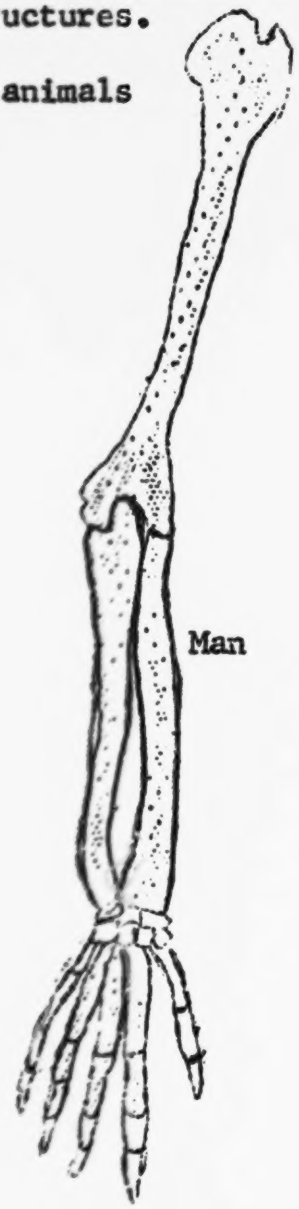
Lizard



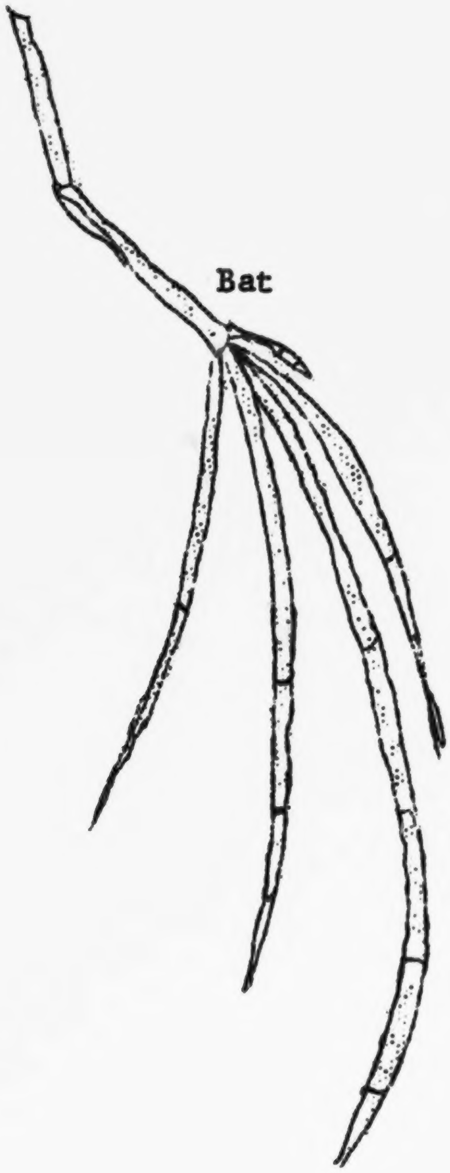
Frog

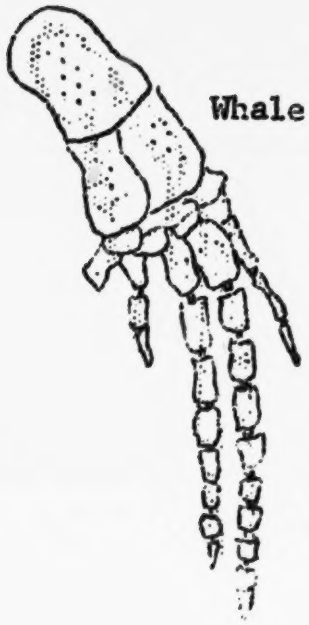


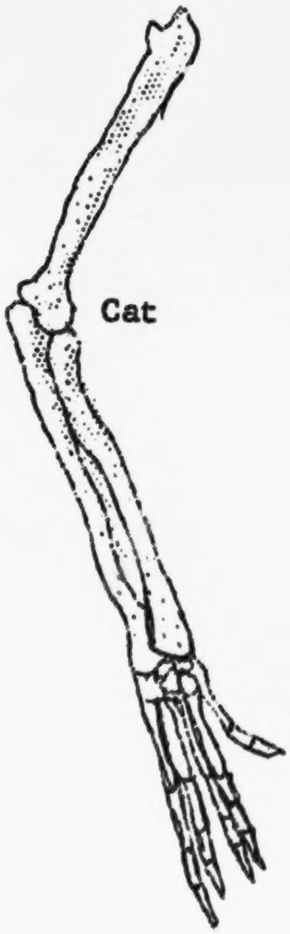
Bird



Man







Students make sketches of analogous structures.

AN INTRODUCTION TO CLASSIFICATION

PURPOSE

To understand the reason for classification in the plant and animal kingdoms

ACTIVITY MATERIALS

Construction paper of various colors
Flocking paper cut in strips for backing
Scissors
Flannel board

WHAT TO DO

Cut circles, squares, triangles, pentagons, hexagon, and octagons from yellow, blue, green, red, orange, any other color. Cut one form from each color. Place a small strip of flocking paper on the back of each cutout. Place the cutouts on the flannel board as shown on figure 1.

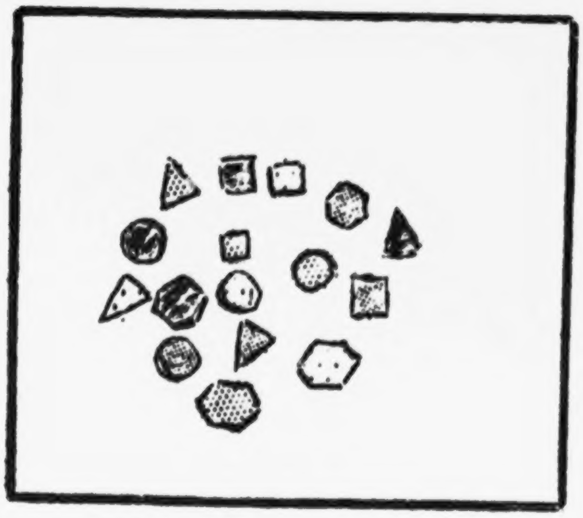


Figure 1

To This ——>

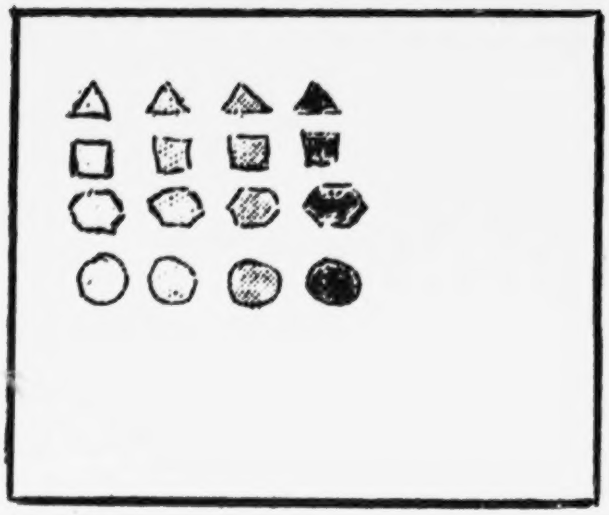


Figure 2

Ask students to decide on some method to make the subject on the flannel board much easier to study. Have students who volunteer come to the flannel board to place geometric forms in some logical order. Perhaps as in figure 2.

Correlate this demonstration with the concept that animals and plants are classified for facility of study and so on.

MAKING COMPARISONS IN LIVING THINGS

PURPOSE

Learning to make comparisons of living things on the basis of structural appearances

ACTIVITY MATERIALS

Living or preserved specimens of

- Euglena
- Paramecium
- Vorticella
- Amoeba
- Bacteria
- Nematode
- Planaria
- Earthworm
- Hydra
- Starfish
- Brittle star
- Liverwort
- Moss
- Lichen
- Sponge
- Mushroom
- Morel
- Slime mold
- Volvox
- Rotifer
- Green Algae
- Pine
- Fern
- Bird
- Millipede
- Centipede
- Spider
- Bread mold
- Crab
- Lobster
- Reptile
- Frog
- Salamander
- Jellyfish
- Snail
- Oyster
- Red algae
- Kelp
- Fish
- Luna Moth

WHAT TO DO

Make a selection of representative specimens, label and number. Place an equal number of representative specimens nearby but without a label but with an identifying number. Students work in groups and compare known specimens with unknown specimens and try to make comparisons. Students try to place unknown specimens in some major phylum with a written statement as to the reason for such a classification. Fill in chart given below.

UNKNOWN	MAJOR CLASSIFICATION	REASONS

MAKING A DICHOTOMOUS KEY

PURPOSE

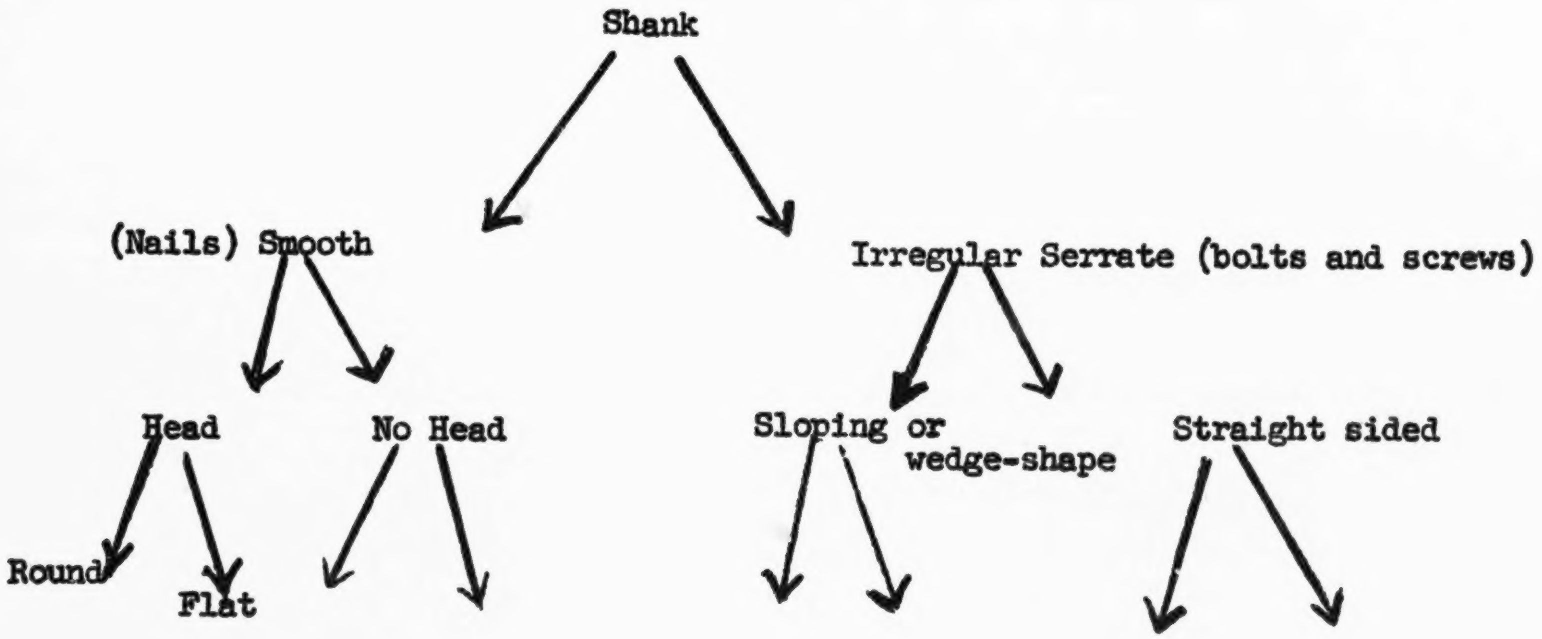
To understand the mechanism of a dichotomous key and how it is used in classification

ACTIVITY MATERIALS

Screws
Bolts
Nails
Paper sandwich bags

WHAT TO DO

Place a variety of bolts and screws and nails in a paper sandwich bag. Pass one bag to each student with directions about the need and use of a dichotomous key. Help students with the first part of the activity and then allow them to figure out the rest of the key by themselves.


Shank
(Nails) Smooth
Irregular Serrate (bolts and screws)
Head
No Head
Sloping or wedge-shape
Straight sided
Round
Flat

UNIT TWO: VARIETY OF LIFE

CONCEPTS TO CONSIDER

The more complex in structure an animal is, the greater is the division of labor among these various structures.

Animals show a gradual increase in complexity in organization.

Sponges illustrate the cellular level in animal structure, cell differentiation without much cell coordination.

Coelenterates illustrate the tissue-level of organization. The organization of cells into tissues is a distinct advance in structure, since various cell functions can be performed better by a group of cells of the same kind acting together than by separate cells.

Animals grouped from flatworms on to man are constructed on an organ-system level construction. Not only do cells work together to form tissues, but tissues of various kinds are closely associated to form one structure called an organ. An organ works with other organs to form a system.

Beginning with flatworms, all higher animals have a mass of cells between the ectoderm and endoderm, called mesoderm.

TEACHING APPROACH (Methods and Activities)

Discuss basic animal characteristics.

- Display animal groups around the room. Students review characteristics of animals from observations and from reading information. List characteristics on the board.
- Review the over-all classification of animals.

Discuss acellularity and multicellularity in lower forms of animal life.

- Review Protists and compare to sponges.
- Display various types of sponges and through a chalk talk and(or) flannel board demonstration show the structure and function of cells.
- Discuss the importance of division of labor on the cellular level.
- Students make a laboratory comparison of protozoans and sponges. See pp. 156-157.

Discuss animals showing tissue level of organization.

- Students make a laboratory comparison of hydra and planaria. See pp. 159-160.
- Discuss symmetry. Give examples of bilateral, radial, spherical, and others
- Aid students in locating posterior, anterior, dorsal, ventral regions in a planarian.
- Discuss the formation of germ layers.
- Assign students to find out the difference between mesoglea and mesoderm.

- Discuss the difference between a colonial organism and a multicellular organism.
- Discuss hydra and planaria through a chalk talk (or) flannel board showing structure and function of various tissues.

Discuss animals showing organ system level of organization.

- Students make a laboratory comparison of ascaris and earthworm. See p.161-163.
- Students write a short paragraph to show development of animals from acellular level, tissue level, and organ-system level and the complexities encountered.
- Prepare a flannel board demonstration to aid students in understanding the organ-systems of the earthworm as compared to ascaris and planaria.
- Discuss the difference between an incomplete digestive tract and complete digestive tract.
- Discuss the development of a true coelom. Discuss segmentation.
- Assign students to report on what effect terrestrial living had on the development of higher forms of animal life.
- Students make a laboratory comparison of crayfish and grasshopper. See pp. 166-168.
- Students report on exoskeleton vs. endoskeleton; incomplete metamorphosis vs. complete metamorphosis and others.
- Present structure and function of parts of crayfish and grasshopper through a chalk talk or flannel board demonstration.
- Students make a laboratory comparison of a clam and starfish. See pp.164-165.
- Discuss the structure and function of parts of a clam and starfish through a chalk talk or flannel board demonstration.
- Display other animals that have similar characteristics as clam and starfish.
- Students make a laboratory comparison of a frog and rat. See pp. 169-170.
- Discuss the structure and function of parts of a frog and rat through a chalk talk or flannel board demonstration
- Display pictures of other animals that have similar characteristics as frog and rat on the bulletin board.
- Use model of frog during chalk talk of structure and function.

DEPTH PROBE

- PROTOZOA AND SPONGES, pp. 156-157 (Average Student Basic Activity)--A laboratory comparison of two animals organized on the cellular level of structural development. Students work in pairs or teams.

- SYMMETRY, p. 158 (Average Student Basic Activity)--To understand the concept of symmetry as applied to structural development of living things. Teacher demonstration.

- HYDRA AND PLANARIA, pp. 159-160 (Average Student Basic Activity)--A laboratory comparison of two animals organized on the tissue level of structural development. Students work in pairs or teams.

- ASCARIS AND EARTHWORM, pp. 161-163 (Average Student Basic Activity)--A laboratory comparison of two animals organized on the organ-system level of structural development. Students work in pairs or teams.

- SNAIL AND STARFISH, pp. 164-165 (Average Student Basic Activity)--A laboratory comparison of two animals. Students work in pairs or teams.

- CRAYFISH AND GRASSHOPPER, pp. 166-168 (Average Student Basic Activity)--A laboratory comparison of two animals with similar characteristics but extremes in environment. Students work in pairs or teams.

- FROG AND RAT, pp. 169-170 (Average Student Basic Activity)--A laboratory comparison of two vertebrate animals showing a significant variation in body plan. Students work in teams.

- PARADE OF ANIMAL LIFE, pp. 171-172 (Slow Learner Basic Activity)--Activities designed to acquaint the student with the complexities of animal life through laboratory comparisons. Students work in teams.

"TOOLS" FOR EXTENDING CONCEPTS

- Plan to show filmstrip (sound) "Insects, Injurious and Beneficial" No. 22

- Plan to show films:

"Crustaceans"	Fsd 595.3-4
"Reptiles"	Fsd 598.1-7
"Insects"	Fsd 595.7-19

- Encourage a student to establish an ant colony in the classroom.

- Culture snails in an aquarium and allow students to observe eggs and watch development.
- Encourage a student to observe and count the number of chirps of a cricket per 10 seconds. Plot a curve to see if there is any relationship between temperature and number of chirps.
- Allow a student to bring in sea shell collection when making comparisons of a clam and a starfish.
- Encourage some students to take a field trip to the beach to make collections of living animals found in tide pools. Review conservation principles with these students first before the field trip.
- Assign a student group to arrange a bulletin board on animal comparisons being made during laboratory periods.
- Assign some students to report on tapeworm, trichinosis, hookworm, malaria, african sleeping sickness.
- Allow some students to read Scientific American, (April, 1959) on Hydra and the "depressing" gas they produce.
- Encourage students to read about habits of starfish and to make a collection of those found on our Southern California coast.
- Encourage students to make collections of frog eggs to watch development and growth.
- Assign a student to report on the book by Karl von Frisch, "The Dancing Bees," New York: Harcourt Brace, 1955.
- Encourage some students to make a laboratory study of Daphnia.
- Stimulate interest in a collection of insects found in student's backyard.

PLANNING AHEAD

- Locate and reserve dried or preserved specimens of mushrooms.
- Collect and store various types of pine cones and pine needles.
- Assign students the task of bringing pond water, river, or lake water in a sample jar for varieties of algae.
- Collect and grow moss and liverworts in terrarium in the classroom.
- Prepare a bulletin board entitled ROSES ARE RED VIOLETS ARE BLUE to show a variety of different flower shapes and to portray the parts of a typical flower.
- Display pine cones and their needles. Students may want to try to identify them. Entitle display DO YOU KNOW YOUR PINES?
- Make a collection of various plants needed in experiment on page 188.
- Collect and display pictures of wildflowers in Southern California.

BROADENING "CONTENT HORIZONS"

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UNIT TWO: VARIETY OF LIFE

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Golden Guide to Fishes. New York: Golden Press
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Textbook References:

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PROTOZOA AND SPONGES

PURPOSE

To be able to compare animals that are organized basically on the cellular level of structural development

ACTIVITY MATERIALS

Paramecia culture (or mixed Protozoan culture)
Slides and cover slips
Various specimens of sponges
Microscopes
Prepared slides of sponge cells

WHAT TO DO

Place a drop of the mixed protozoan culture on a slide and cover. Observe under low-power. Study the movements of the various types of protozoans. How many different kinds can you describe? Make a list and sketch the parts of various protozoans which enable them to move about. Note the manner in which many protozoans take in food. Give a description of your observations. Using your textbook as a reference and your microscopic observations fill out the chart given at the end of this exercise.

Examine dried specimens of sponge. If any fresh-water sponges are available observe them under low-power of the microscope. Make a sketch of the dried specimen and a sketch of cells of fresh-water sponge. Do any of the sponge cells resemble protozoans? If so, why? What is the most obvious difference between the sponge and the protozoan? Why are sponges and protozoans said to have a cellular level of organization? Using prepared slides of various types of sponge cells, make observations under low-power and draw several different types of cells and try to guess their function. Using references, textbook, and your observations, complete the chart given at the end of this exercise. How do sponges bring in food?

	PROTOZOA	SPONGES
Level of Organization		
Type of Food		
Locomotion		
Waste Removal		
Nervous Reactions		
Reproduction		
Other Comments Evolutionary Differences		

SYMMETRY

PURPOSE

To understand the concept of symmetry as applied to structural development

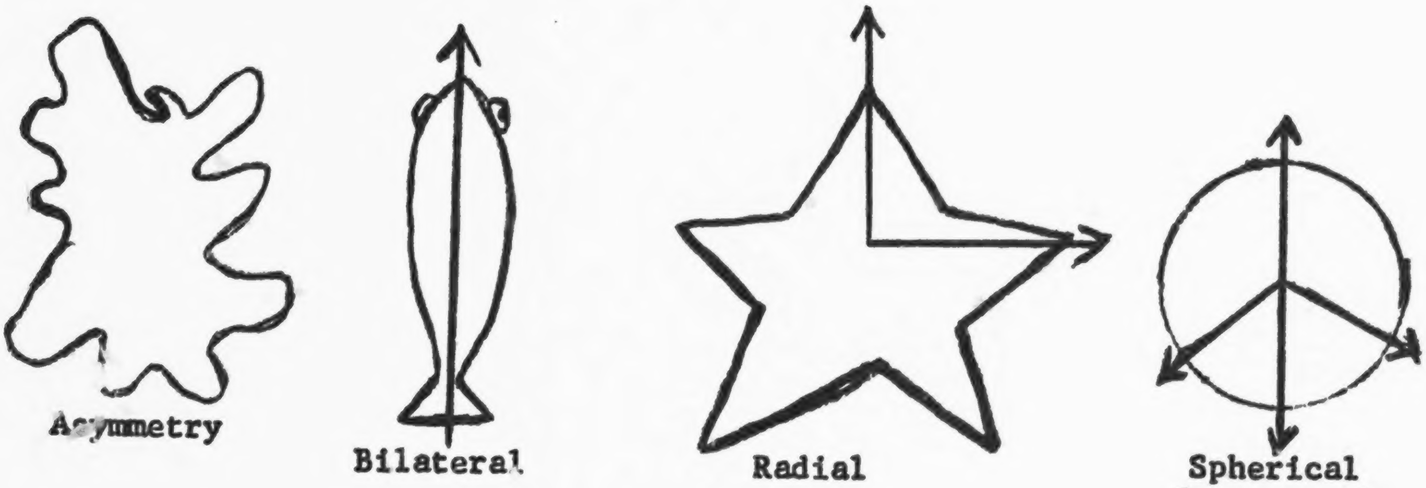
ACTIVITY MATERIALS

Flannel board cutouts showing various types of symmetry
asymmetry, bilateral, radial, spherical (or universal)

Specimens of sea anemone, clam, fish, crayfish, Ascaris worm, grasshopper, frog, and earthworm

WHAT TO DO

Place an example of each of the above specimens in groups. Students work in teams. Determine the symmetry of each of the specimens in the group. Students make a list of other animals that have a similar symmetry.



Asymmetry Bilateral Radial Spherical (Universal)

Samples of flannel board cutouts

HYDRA AND PLANARIA

PURPOSE

To be able to compare two animals such as the Hydra and Planaria which are organized basically on the tissue level of structural development

ACTIVITY MATERIALS

Dissecting needles
Green hydra*
Planaria*
Raw liver
Microscope and stereoscope (if available)
Slide and cover slips
Mixed protozoan culture*
Stock aquarium water
Watch glasses or Syracuse glasses

Prepared slides of hydra showing cross sections of tissue layers
Prepared slides of planaria showing cross sections of tissue layers

WHAT TO DO

Examine a specimen of a living green hydra and a planaria. Observe the movements of each under the stereoscope (if available) or low-power of microscope. Describe the typical movements of each animal. Be sure that each specimen is placed in a separate watch or syracuse glass for the examinations.

Add a drop of rich protozoan culture to the water of each specimen. Which animal shows feeding taking place? Make observations under low-power or under a tripod lens. How does the feeding animal take in food? Place a small piece of raw liver in each dish. Which animal shows feeding taking place? How does the feeding animal take in food? Make observations under low-power or tripod lens.

Which of the two animals has a definite "head"? Does the hydra have a mouth? Does the planarian have a mouth? What type of digestive tract is found in the hydra? In the planaria?

Jar the dish containing the hydra. What happens? Jar the dish containing the planarian. What happens? Touch each animal with a dissecting needle. What happens in either case?

Which of the animals show sensitive "eye spots"? Can you guess at its function? Which of the animals has tentacles? Can you guess at its function?

Observe prepared slides of hydra and planaria. Make drawings of the cross section of each type of animal. What are some essential differences from this observation?

---

*Secure Planaria and Green Hydra on fresh materials order from Science Center or make collections from neighboring ponds or streams.

Using a textbook or other reference and information gathered from observations, fill in the following chart.

	HYDRA	PLANARIA
Level of Organization		
Number of Cell Layers		
Locomotion		
Type of Food		
Symmetry		
Nervous Reactions		
Waste Removal		
Digestive Openings		
Reproduction		
Other Comments: Evolutionary Differences		

ASCARIS AND EARTHWORM

PURPOSE

To be able to compare two animals organized basically on the organ-system level of structural development

ACTIVITY MATERIALS

Preserved Ascaris
Live earthworms and preserved earthworms
Vinegar
Live vinegar "eels"
Tripod lens
Camel's hair brush or small paint brush
Scalpel, teasing needle, scissors
Watch glass (or Syracuse glass or half of a petri plate)

WHAT TO DO

Place a preserved specimen of Ascaris in a half petri dish and a live earthworm in the other half of the dish. Feel the outer surfaces of both animals. What are the obvious differences in this comparison?

Allow the earthworm to move between your thumb and forefinger. How does the earthworm cause this movement? Are there any rough spots on the surface? If so, examine them with a tripod lens.

Examine the Ascaris and earthworm for a mouth and an anus. Does Ascaris have both openings? Does the earthworm have both openings? (A projecting lobe or lip in front of and above the mouth is the anterior end of the worm). In which worm is a "head" most prominent?

Using a dissecting pan (if available) or a square of corrugated cardboard, make a longitudinal incision through the body wall of the earthworm and pin the body wall onto the cardboard square with straight pins or dissecting pins. (Start at the anterior end and cut along the dorsal surface) Write a short paragraph giving a description of the body cavity, digestive tube, blood vessels, and other organs. Use textbook for reference on location and information.

Do the same dissection in the preserved specimen of Ascaris. Make a comparison of the earthworm and Ascaris. Write a short paragraph describing the body cavity, digestive tube, blood vessels, and other organs. Use textbook for reference on location of parts and other information.

Examine a cross section cut of a preserved earthworm through a tripod lens. Is the nerve cord ventral or dorsal. How many sets of muscles can be seen? How many excretory organs are found in each segment? How many blood vessels can be seen on this cut? What is the shape of the digestive tube cavity? Why is it this shape? (Typhlosole)

Shine a beam of light on a living earthworm that has been kept in a dark container. What are its reactions? Place a small amount of vinegar with a camel's hair brush on the skin of an earthworm. How does it react? Touch the worm at several places with a pencil point. How does it react?

Obtain vinegar "eels" for examination as a living roundworm. Note the movement of this worm.

Fill the chart shown on the next page with information from textbook, references, and observations made during the laboratory exercise.

	ASCARIS	EARTHWORM
Level of Organization		
Digestive Organs		
Segmented Externally		
Segmented Internally		
Nervous Reactions		
Circulation		
Locomotion		
Waste Removal		
Reproduction		
Other Comments: Evolutionary Differences		

SNAIL AND STARFISH

PURPOSE

To understand and compare two animals with similar environment but different body plans

ACTIVITY MATERIALS

Dried or preserved specimens of starfish, sea urchins, sand dollars
(If available fresh specimens of starfish)
Preserved or canned clams or aquarium snails
Lens

WHAT TO DO

Observe the movement of a living snail with a hand lens on the inside wall of an aquarium or glass beaker. How is the snail able to cling to the side of the container? How is it able to move? What is the shape of the "foot" when it is extended? When it is at rest?

Are sense organs noticeable? Where are they located? What kind of sense organs are they?

Shred a small piece of lettuce leaf into tiny sections and make some stick to the wall of the aquarium in the snail's path. Observe with a hand lens. What does the snail do? Does it have a mouth? Where is it located?

Allow snail to be pulled away from the aquarium wall. Drop the snail to the bottom. What happens? What does it do after it has been on the bottom for a while?

Pass around specimens of starfish, sea urchins, and others. Examine the rough spiny skin. Is there a definite pattern? Is it a random pattern?

(Optional): If a living starfish is available in a salt water aquarium, place one on its back (dorsal side down). What is it trying to do?

Feed the starfish a living clam or mussel or freshly killed fish. How does the starfish feed? Where is its mouth? Where is its stomach?

UNIT TWO: VARIETY OF LIFE

Watch the starfish move along the aquarium. What enables it to move? Place a small mop along the dorsal side of a starfish. Wait for a short time and see if the strings of the mop are being held fast by the starfish. What is the purpose of this? What organ is found on the starfish which enables it to do this?

Fill in the summary chart below with information gathered from textbook, references, and laboratory observations

	SNAIL	STARFISH
Level of Organization		
Respiration		
Circulation		
Digestion		
Nervous Reactions		
Reproduction		
Other Comments Evolutionary Differences		

CRAYFISH AND GRASSHOPPER

PURPOSE

To understand and compare two animals with extremes of environment, terrestrial and aquatic

ACTIVITY MATERIALS

Crayfish (live and preserved)
Grasshoppers (preserved)
Brom thymol blue
Teasing needles
Ink
Enamel pans and clear water

WHAT TO DO

Examine a preserved crayfish and a preserved grasshopper for external appearance.

How many body parts are there in the grasshopper? In the crayfish? Which animal shows a fusing of body parts? Which animal shows segmentation of body? How many legs in grasshopper? In the crayfish? Can you guess the function of the legs (appendages) of the crayfish? Can you guess the functions of the legs of a grasshopper? Which animal has jointed legs?

Place a live crayfish in a white enamel pan containing clear water. Place a drop of brom thymol blue directly behind the animal. What observations can be made from this? Which appendages help in this function? Can the crayfish swim? Which appendages help in this function? Can a crayfish walk? Which appendages help in this function?

Examining a preserved crayfish, gently lift the carapace and examine the gills. Carefully examine the point at which each appendage is attached to the body. What kind of organ is found at these attachments? What is the function of these organs?

Examine the sides of the abdomen of a preserved grasshopper. Using a hand lens or stereoscope see if you can locate small openings. Of what use can these openings be? Are they found at random or is there a definite pattern? Describe?

Examine the eyes of a preserved grasshopper. How many can you find? Are they compound or single? What is a compound eye? Are there ears? Where, if any, are they located? Describe?

Examine the eyes of a crayfish. How many can you find? Are they compound or simple? What major difference can you describe between the eyes of the crayfish and the grasshopper?

Does the crayfish have ears? Where are they located?

How many antennae, if any, are found on the crayfish? In the grasshopper? Where are each generally located? What is the general function of this organ?

Gently lift the upper lip of a preserved grasshopper with a dissecting needle. What is located beneath the lip? In what manner do these parts move? In what manner do the parts move in a crayfish? What is the major function in a crayfish? In a grasshopper?

Locate small openings at the base of the first antennae in a crayfish. Of what importance are these openings? Locate similar pores in the grasshopper. Of what importance are these openings?

Fill in the chart given below with information taken from references, textbook, and observations made during the laboratory period.

	CRAYFISH	GRASSHOPPER
Level of Organization		
Structures for Respiration		
Number of Body Parts		
Skeleton		
Nervous Reactions		
Waste Removal		
Special Uses of Appendages		
Growth		
Reproduction		
Other Comments: Evolutionary Differences		

FROG AND RAT

PURPOSE

To understand and compare two vertebrate animals such as the frog and the rat

ACTIVITY MATERIALS

Frogs (living and preserved)
Frog skeleton (if available)
Rat skeleton (if available)
Rat (live and preserved)
Flashlight
Ruler

WHAT TO DO

Examine a frog and rat skeleton. Observe the differences between the two. How many different types of teeth can be found in the frog? How many different kinds can be found in the rat?

Observe a living frog and a living rat. Notice the breathing movements of each. How do they differ? Which of the animals has a well-developed rib cage? Can you make an educated "guess" about the relationship of breathing and structure of rib cage?

Observe the locomotion of the frog and the rat. What are the obvious differences' How are the front legs attached to the backbone in a frog? How are the back legs attached to the backbone in a frog? How are these same bones attached in the rat? How does the pectoral and pelvic girdle differ in the two animals? How many bones are found in each girdle?

If rat and frog skull are available, fill each with sand. Weigh just the sand that fills each cavity on a balance scale. Is there any difference? If it is possible to weigh the skeletons do so. If not, measure the width, depth, and length of the skeleton. What is the relationship of the brain cavity to the size of the animal?

Hold a frog in your hand and try to determine the difference in temperature, do the same with a rat (use extreme care). Which one of the animals would you consider to be warm blooded? What is the difference between warmblooded and coldblooded?

UNIT TWO: VARIETY OF LIFE

Place frog and rat in a dark box for about 5 minutes. Using a penlight or flashlight, shine a beam of light into a frog's eyes. What is the result or reaction? Do the same with a rat. What is the reaction? Do the same with your teammate. What is the reaction?

Fill in the chart given below with information taken from references, textbook, and observations made during the laboratory period.

	FROG	RAT
External Covering		
Teeth		
Rib Cage		
Skull Cavity		
Pupil (eye) Reaction		
Other Comments: Evolutionary Differences		

PARADE OF ANIMAL LIFE

PURPOSE

To better understand the complexity of animal structure

ACTIVITY MATERIALS

Wall charts of various animals listed below
(Flannel board cutouts of same or ditto sheets of various animals to be studied)
Clay (modeling)
Colored pencils
Crayolas

WHAT TO DO

Protozoa and Sponges

Students may observe dried specimens of sponges and examine living protozoa under the microscope. Prepared ditto sheets of the various body plans of each animal group are completed by the student and then colored in with coloring pencils. Some students may wish to model some protozoan forms out of modeling clay.

Hydra and Planaria

Students may observe living and prepared specimens under the microscope and stereoscope. Prepared ditto sheets of the various body plans of each animal group are completed by the student and then colored in with coloring pencils. Chalk talk or flannel board demonstration of animal structures should be given to aid student's understanding.

Ascaris and Earthworm

Students may observe preserved specimens of Ascaris and earthworm. Prepared ditto sheets of the various body plans of each animal group are completed by the student and then colored in with coloring pencils. Chalk talk or flannel board demonstration should be given to aid student's understanding.

UNIT TWO: VARIETY OF LIFE

Crayfish and Grasshopper

Students may observe living and preserved specimens. Prepared ditto sheets of the various body plans of each animal group are completed by the student and then colored in with coloring pencils. Chalk talk or flannel board demonstration of animal structures should be given to aid student's understanding.

Frog and Rat

Students may observe living and preserved specimens of frog and rat. Display skeletons of each animal. Prepared ditto sheets of the various body plans of each animal group are completed by the student and then colored in with coloring pencils. Students may make a paper skeleton of each animal. Chalk talk or flannel board demonstration of animal structures should be given to aid student's understanding.

UNIT TWO: VARIETY OF LIFE

CONCEPTS TO CONSIDER

Plants show an increasing complexity of structure in organization.

Thallophytes are the simplest plants without true roots, stems, or leaves showing little differentiation of tissue and not forming embryos.

Mosses and liverworts are first green land plants. They are non-vascular plants with restricted size growing close to the ground.

Tracheophytes are plants with tissues for conducting water and dissolved materials.

Seed plants are divided into two groups on the basis of their reproductive structures.

Gymnosperms are seed plants which bear seeds usually exposed on the plant.

Conifers are the largest group within the classification Gymnosperms. These plants generally bear their seeds in structures called cones.

The structure common to all species of Angiosperms is the flower. Its major function is the formation of seeds in reproduction.

Plants alternate a diploid (spore-bearing) sporophyte generation with a monoploid (gamete-bearing) gametophyte generation.

TEACHING APPROACH (Methods and Activities)

Discuss basic plant characteristics.

- List the basic plant characteristics on the board during class discussion.
- Students prepare a chart showing a comparison between plant and animal characteristics (in review).

Discuss lower plant forms.

- Students make a laboratory comparison of algae and mushrooms.
- Display other types of fungi, such as bread mold, bacteria, bracket fungi, morels, earth stars, etc.
- Student teams use references and gather material and information on edible and non edible mushrooms.
- Students may report on pollution of reservoirs and other related water storage facilities by various forms of fresh-water algae.
- Students may prepare a three-dimensional model of a fresh-water algae, Spirogyra. See page 181 for directions.

Discuss more complex plant forms.

- Students make a laboratory comparison of the moss and the fern.
- Prepare ditto sheets showing the life cycle of the moss and the fern.
- Display various types of moss and fern. Give a chalk talk or flannel board demonstration on the structure and life cycle of moss and fern.
- Encourage some students to grow fern prothallia as suggested on p. 184.
- Students learn about the reproductive cycle in the pine through a laboratory investigation.
- Prepare a display of various types of conifers and cones.
- Students bring in various types of conifer leaves for identification. Reference--Baerg, H. J. How to Know the Western Trees. Dubuque, Iowa: William Brown Co., 1955.
- Assign students the task of bringing to class a variety of leaves, flowers, and seeds of seed plants (other than conifers).
- Prepare a display of flowers.
- Discuss the basic characteristics of monocots and dicots.
- Students make a laboratory comparison of monocot and dicot plants. See pp. 186-189.
- Prepare ditto sheets of the "key" shown on pp. 192-193.
- Ask students to make comparisons of two or more kinds of plants. They will discover as a result of this scoring that the simpler plants show a low score, while the more complex plants show a high score. See p. 191.
- Discuss the function, structure, and life cycle of monocot and dicot plants through a chalk talk or flannel board demonstration.

DEPTH PROBE

- ALGAE AND MUSHROOMS, pp. 179-181 (Average Student Basic Activity)--A laboratory comparison of two simple plants, one being able to photosynthesize food while the other is saprophytic. Students work in pairs or groups.

- MOSSES AND FERNS, pp. 182-183 (Average Student Basic Activity)--A laboratory comparison of two plants to emphasize the development of vascular systems. Students work in pairs or groups.

- GROWING FERN PROTHALLIA, p. 184 (More Able Student Basic Activity--Optional)--To observe the development of the gametophyte generation of a fern plant. Students work individually or in groups.

- CONIFERS, pp. 185 (Average Student Basic Activity)--To learn the structure and reproductive cycle of a pine. Students work in groups or pairs.

- MONOCOTS AND DICOTS, pp. 186-189 (Average Student Basic Activity)--A laboratory comparison of two groups of flowering plants--monocots and dicots. Students work in pairs or groups.

- COMPARISON OF TWO OR MORE KINDS OF PLANTS, pp. 190-193 (Average Student Basic Activity)--Learning how to use a "key" in scoring simple and more advanced characteristics in plants. Students work in pairs or groups.

"TOOLS" FOR EXTENDING CONCEPTS

- Students bring in a variety of leaves and try to make a dichotomous key for identification.
- Find simple keys for identification of common garden flowers. Students work in groups to identify flowers from a garden.
- Students collect pictures of wildflowers of Southern California and prepare a notebook of these pictures with classification of each flower.
- Preview the filmstrips "Plant Families" and "Growing New Plants," which are titles included in the set "The Wonderland of Science," S-106.
- Borrow the set of 2" x 2" slides, "California Wild Flowers," Set 1 -- S-1 from Audio-Visual Center.
- Show films:
    - "Simple Plants: Algae and Fungi," Fsd 589-1
    - "Life of the Molds," Fsd 589-2
    - "Flowers at Work," Fsd 582.13-2
    - "Leaves," Fsd 581.4-1
    - "Gymnosperms"
    - "The Fungi"
- Encourage some students to build a three-dimensional model of a typical flower for class demonstration.
- Assign a student group to prepare a bulletin board on SEED STRUCTURE AND SEED DISPERSAL.
- Assign some students to make reports on Luther Burbank and other well-known plant breeders.
- Encourage students to bring in their favorite potted plants for a classroom display on plant families.
- Encourage some students to collect saltwater algae and prepare herbarium specimens of different varieties found on the Southern California coast.
- Display a variety of fruits.

- Encourage some students to read Scientific American articles "What Makes Leaves Fall" (November, 1955), "Molds and Men" (January, 1952), and "The Flowering Process" (April, 1958).
- Assign some students the task of researching the origin of cultivated plants in the United States.
- Assign students to report on poisonous plants of United States and Southern California.

PLANNING AHEAD

- Collect and reserve reprints of article, Cooper, Charles. "The Ecology of Fire," Scientific American, (April, 1961) for laboratory exercise in unit three.
- Prepare cutouts for flannel board on food pyramids and food chains. See page 206.
- Collect and store corks and rubber stoppers for experiment described on page 204. Prepare Brom thymol blue solution and order snails and Elodea sprigs from the Science Center on fresh materials order.
- Store a large quantity of stock aquarium water for the experiment on page 204.
- Assign student teams the task of preparing bulletin board display on unusual food chains and food webs.
- Purchase a large roll of heavy aluminum foil.
- Check chemicals to be used in yeast population study. You will need yeast extract, peptone, potassium phosphate (monobasic),glucose, and distilled water.
- Encourage some students to report on Strontium-90 in the calcium cycle.
- Assign some students to the task of keeping a balanced microcosm at home and reporting facts about it once a week for the semester.
- Encourage some students to study a fresh-water pond. Include in the study the birds seen, plants growing in, around, and near the pond, water from the bottom, middle, and surface of pond; animals found living in each of the areas of the pond bottom, middle, and surface waters.
- Encourage some students to make a collection of fresh-water pond organisms to bring to the school laboratory for investigation by entire class.
- Assign students to bring in samples of topsoil, clay soil, sand, and other types of soil for experiment on page 217.
- Collect articles from newspapers and magazines on floods and flood control, fire and fire prevention in Southern California.
- Prepare a bulletin board for Conservation Week, March 7-14. Discuss important conservation practices.
- Assign a student to report on smog and its effects on plant and animal populations.

- Encourage some students to report on a variety of predator-prey relationships and to prepare cutouts to visualize their reports.
- Reserve books on ecology in the school library.
- Encourage a student to prepare a three-dimensional pyramid for display when talking about energy relationships, food pyramid, pyramid of numbers, or pyramid of mass.
- Assign some students the task of making three-dimensional cutouts of plants and animals to be used in experiment on food web. See page 207.

BROADENING "CONTENT HORIZONS"

Teacher References:

Sinnott, E. W., and K. S. Wilson. Botany: Principles and Problems. New York: McGraw-Hill, 1955.

Jepson, W. L. A Manual of Flowering Plants of California. Berkeley: University of California Press, 1928.

McMinn, Howard. An Illustrated Manual of California Shrubs. Berkeley: University of California Press, 1951.

McMinn, Howard, and Evelyn Maine. Pacific Coast Trees. Berkeley: University of California Press, 1947.

Edmonson, W. T. Ward and Whipple's Fresh-Water Biology. 1959.

Benson, L. Plant Classification. New York: Heath Co., 1957.

Machlis, L., and J. Torrey. Plants in Action: A Laboratory Manual of Plant Physiology. San Francisco: Freeman and Co., 1959.

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Smith, G. The Fresh-Water Algae of the United States. New York: McGraw-Hill, 1950.

UNIT TWO: VARIETY OF LIFE

Student References:

Baerg, H. How to Know Western Trees. Dubuque, Iowa: Wm. Brown Co., 1955.

Jaques, H. E. How to Know Weeds. Dubuque, Iowa. Wm. Brown Co., 1959.

Jaques, H. E. How to Know Plant Families. Dubuque, Iowa: Wm. Brown Co., 1949.

Cuthbert, M. J. How to Know Fall Flowers. Dubuque, Iowa: Wm. Brown Co., 1948.

Cuthbert, M. J. How to Know Spring Flowers. Dubuque, Iowa: Wm. Brown Co., 1949.

Prescott, G. How to Know Freshwater Algae. Dubuque, Iowa: Wm. Brown Co.

Conrad, H. F. How to Know Mosses and Liverworts. Dubuque, Iowa: Wm. Brown Co.

Pohl, R. W. How to Know Grasses. Dubuque, Iowa: Wm. Brown Co.

Dawson, E. Y. How to Know Seaweeds. Dubuque, Iowa: Wm. Brown Co.

Jaques, H. E. How to Know Trees. Dubuque, Iowa: Wm. Brown Co., 1946.

Scientific American. Plant Life. New York: Simon and Schuster, 1957. (Title III - Collection)

Cronquist, A. Introductory Botany. New York: Harper, 1961.

Bonner, J., and A. Galston. Principles of Plant Physiology. San Francisco: Freeman and Co., 1952.

Zim, H. Golden Nature Guide to Trees. New York: Golden Press

Zim, H. Golden Nature Guide to Flowers. New York: Golden Press

Hylander, C. J. World of Plant Life. New York: Macmillan Co., 1956.

Cobb, B. A Field Guide to Ferns. Boston: Houghton-Mifflin Co., 1956.

Needham, James, et al. A Guide to Study Freshwater Biology. Ithaca, New York: Comstock, 1962.

Textbook References:

Moon, Otto, and Towle. Modern Biology. pp. 91-144

Smith, Ella Thea. Exploring Biology, 5th Edition. pp. 82-90 102-151

ALGAE AND MUSHROOMS

PURPOSE

To understand and compare two kinds of plants, both considered to be primitive, one kind being able to photosynthesize its food while the other is saprophytic in nature.

ACTIVITY MATERIALS

Culture of algae
Variety of mushrooms
Brom thymol blue solution
Pipettes
Slides and cover slips
Microscopes
Razor blade
Forceps
Thin cardboard
Mucilage (or egg white)
Glass dish

WHAT TO DO

Examine a culture of algae. Draw out a fine green "thread" of material from the culture. How does it feel? Place a few of these threads in a drop of water on a slide and cover. Observe under the low-power and then the high-power. What is the major structure of the filament? Are all the filaments exactly alike? Are the chloroplasts in these filaments exactly alike? How do they differ? Stain the alga with iodine solution. Is there any starch located in the filament? If so, where is the starch located? Of what use is this starch to the alga?

Make sketches of many different types of algae that you see. Use reference: Needham, James, et al. *A Guide to Study Freshwater Biology*. Ithaca, New York: Comstock, 1962, to help identify the different forms.

Examine the mushroom and identify the parts such as: gills, stalk, cap (pileus). Using a razor blade or scalpel cut a mushroom in two by cutting down through the cap and stalk. Remove a portion of the gill. Place the gill in a drop of water on a slide and observe under low-power of the microscope. How many spores are located on the gill? How are they attached to the gill? Are they located inside or outside of the gill?

Place Brom thymol blue in a small test tube. Place this test tube in a larger test tube. Place several pieces of fresh mushrooms such as caps and stalks into large test tube but not in smaller tube containing Brom thymol blue. Place a tight stopper into large test tube and examine after several hours. What has happened to the Brom thymol blue? Why? Would the set-up be different if it had been kept in the dark? (Figure 1)

Spread a thin coat of mucilage-water mixture (or egg white) over a thin piece of cardboard. Remove the stem part of the mushroom, leaving only the cap of a fully-opened mushroom. Push 4 toothpicks into the side of the mushroom cap. Rest the ends of the toothpicks on small blocks so that the cap is suspended a short distance from the cardboard. Cover with an overturned glass dish and leave undisturbed for 24 hours. Millions of spores will fall on the sticky surface, which is kept moist by the damp air under the dish. When the dish and cap are removed, the surface will dry and leave a permanent print. For mushrooms that have light colored spores use a dark paper to make the print. (Figure 2)

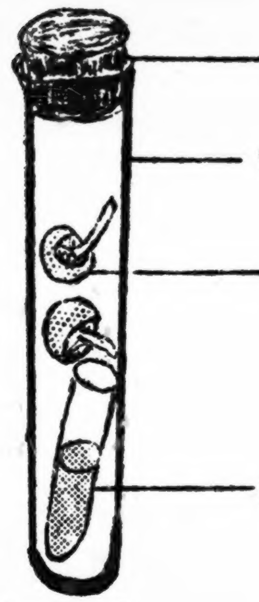

Stopper
Test tube
Mushroom caps and stalks
Brom thymol-blue in small tube

Figure 1

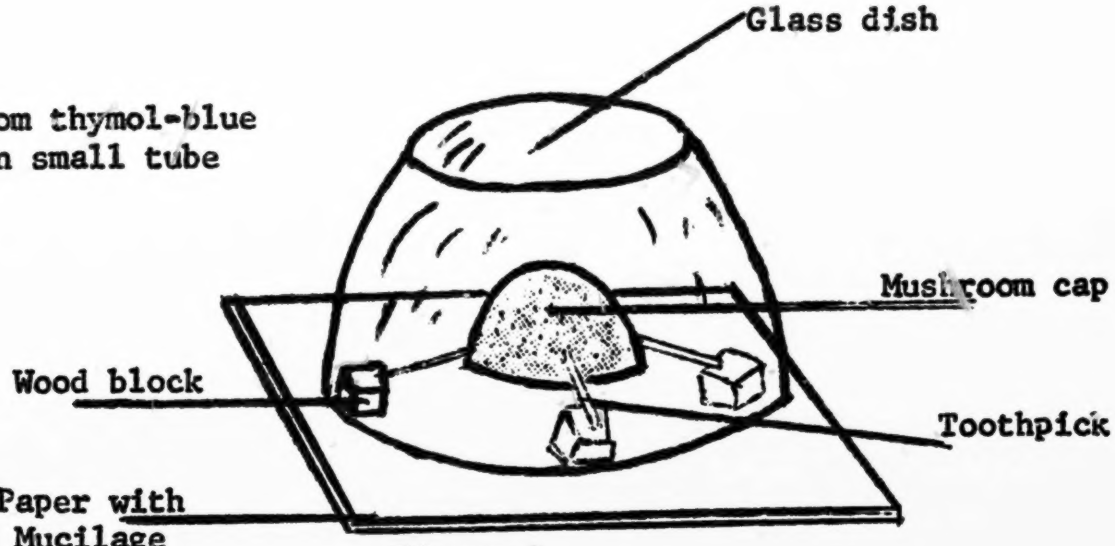
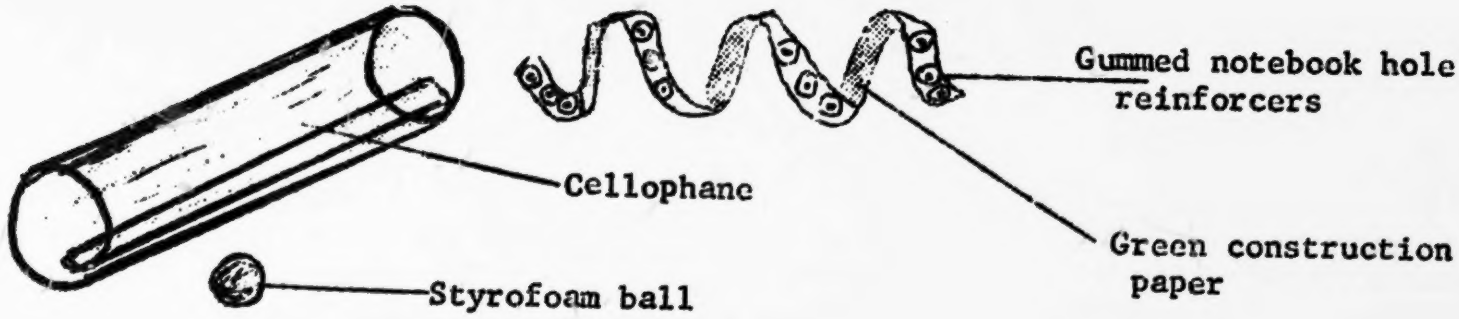
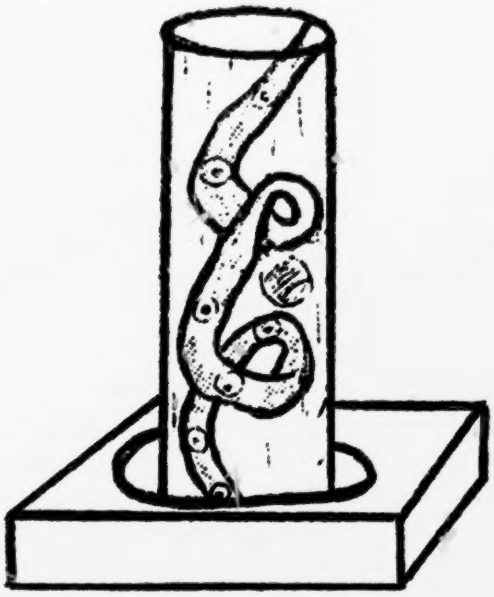

Glass dish
Mushroom cap
Wood block
Toothpick
Paper with Mucilage

Figure 2

Suggest to a member of each team to construct a three dimensional model of Spirogyra. Take a piece of heavy cellophane or transparent acetate and roll it into a cylinder. Use scotch tape to keep the rolled edges together. Suspend a ping pong ball or small styrofoam ball within the cylinder to represent the nucleus. Cut thin strips of green construction paper to represent the spiral chloroplasts and place gummed notebook hole reinforcers on the green strips to represent the pyrenoids. Strips of cellophane may be used to represent threads of cytoplasm and also to help suspend the nucleus. Place the entire model into box top which has been cut just to fit cylinder of heavy cellophane. (Figure 1)


Gummed notebook hole reinforcers
Cellophane
Green construction paper
Styrofoam ball



Finished model of Spirogyra

MOSSES AND FERNS

PURPOSE

To understand and compare two kinds of plants to demonstrate development of conducting systems (vascular systems)

ACTIVITY MATERIALS

Moss plants
Prepared slides of cross section of gametophyte of fern and moss
Fern fronds
Teasing needles
Microscope
Cover slips and slides
Pipettes
Forceps

WHAT TO DO

Examine the moss plant under a stereomicroscope. Notice the cluster of leaves at the top of the various plants. Are they all the same? How are the leaves of the moss plant veined? Does the plant have roots? Stems?

Examine prepared slides of the male and female gametophytes of the moss. How do they differ in structure? Make sketches of each kind of organ.

Examine a fern frond. Notice on the underneath side of some of the leaves are small rust dots. Scrape one of these dots onto a slide. Add a drop of water and cover. What kind of structures make up the rust dot? What kind of structure is released?

Examine a prepared slide of the gametophyte of a fern. What is its shape? Where are the male and female organs located on this structure?

What kind of veining does the fern leaf have? Does the fern plant have stems, and roots?

Summarize information about moss and fern in chart given below from laboratory observations, reading and reference material.

	MOSS	FERN
True Roots		
True Stems		
True Leaves		
Reproduction		
Habitat		

UNIT TWO: VARIETY OF LIFE

GROWING FERN PROTHALLIA

PURPOSE

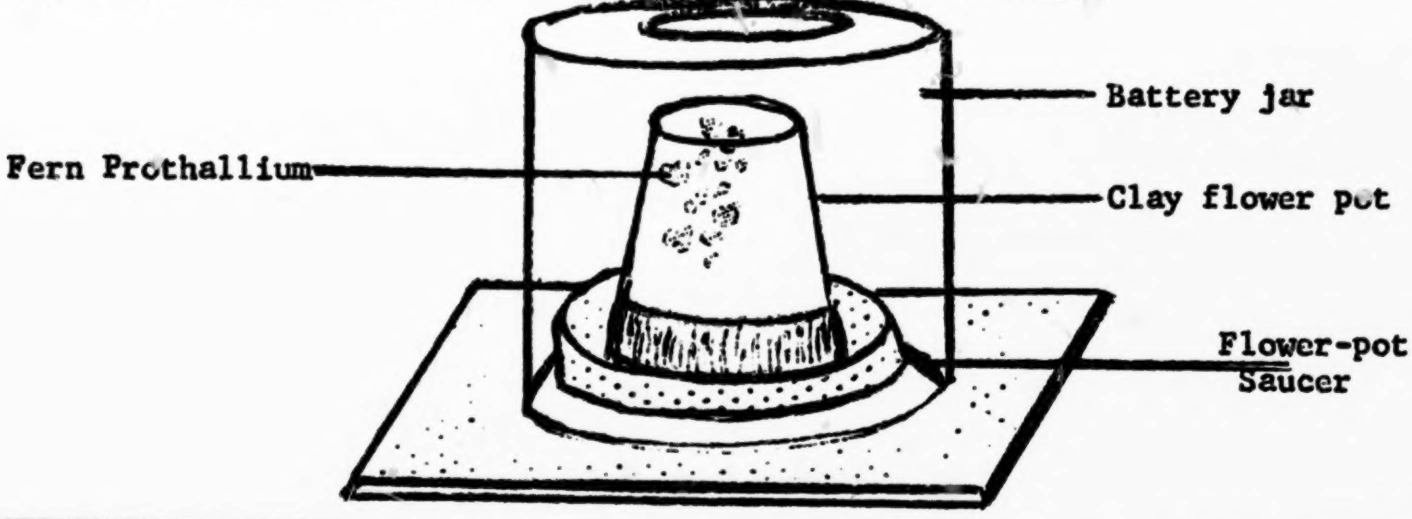
To observe the development of the gametophyte generation in a fern plant

ACTIVITY MATERIALS

Newspaper or paper toweling
Flower pot
Bell jar (gallon battery jar)
Fern spores
Pan (or clay saucer)

WHAT TO DO

Collect fern leaves with mature sori and place in a box for drying (two or three days). Thoroughly clean a 3- to 4-inch flower pot and fill with peat, sphagnum moss, or pieces of paper toweling or newspaper. Moisten and pack tightly. Invert this pot in a flower-pot saucer (or pan) and fill with water. Set pot and saucer on a piece of glass and invert a glass container, such as a gallon battery jar or bell jar, over it. If battery jar is not available, use smaller flower pot and large beaker. Shake the dry spores over the moist surface of the inverted flower pot. Replace the glass cover and place in a cool location with reduced light. Add water to the saucer frequently. Prothallia will develop in about 8 to 10 weeks.



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Morholt, Brandwein, and Joseph. A Sourcebook for the Biological Sciences. New York: Harcourt, Brace, 1958. p. 395.

Miller and Blaydes. Methods and Materials for Teaching Biological Sciences. New York: McGraw-Hill, 1938. p. 229.

CONIFERS

PURPOSE

To understand the structure and reproductive life cycle of a pine

ACTIVITY MATERIALS

Several pine branches with cones of various sizes and ages
Microscope
Slides and cover slips
References

WHAT TO DO

Examine a branch of pine with cones of different kinds attached. What kind of leaves are found on the specimen? How many leaves are found on each stalk of your specimen?

Examine the different cones on the plant. Are there any pollen cones? How are you able to identify pollen cones? How many of these cones occur in a cluster? Shake a pollen cone near a slide with water on it. Observe the pollen grains under low and high power of the microscope.

What other kinds of cones are found on the branch? Pull off one of the woody bracts and remove the thin membranous seed. What function does the thin membrane have? Are all the woody bracts open? What is the sticky material exuded by the cone? What is its main purpose?

Make a drawing of a woody bract showing the seed location. Make a drawing of the pollen grain. Examine prepared slides of a longitudinal section of a ovule.

Use textbook and other references to make a drawing of the life cycle of a pine. Label all parts of the drawing carefully and write a short summary of the life cycle.

UNIT TWO: VARIETY OF LIFE

MONOCOTS AND DICOTS

PURPOSE

To understand and compare two groups of flowering plants, Monocots and Dicots, by studying structural appearances

ACTIVITY MATERIALS

Bean and corn seeds (Kidney, Navy, and Lima)
Monocot and dicot flowers
Razor blade
Apple, grape, tomato
Acorn, bean or pea pod
Scalpel
Tripod lens or stereomicroscope

WHAT TO DO

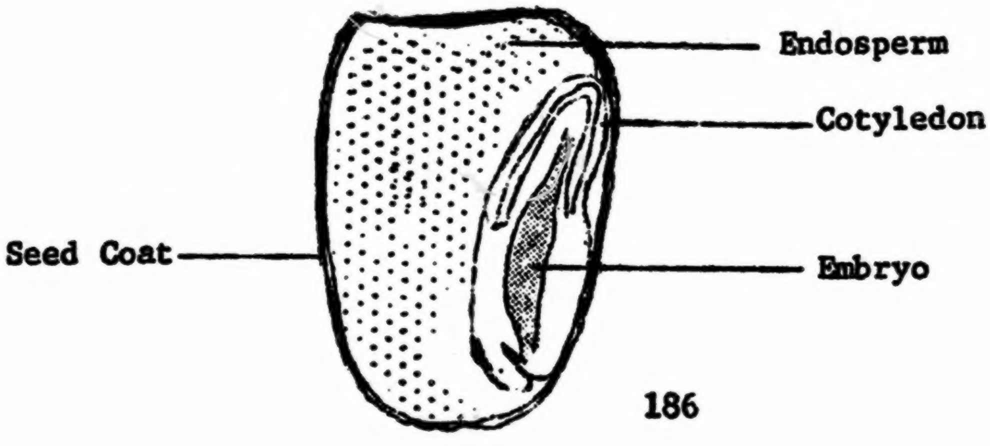
Plant bean (Kidney or Navy) seeds two weeks in advance of this lesson. Make additional plantings at least three days apart thereafter to be assured of an adequate range of developmental stages. Do the same for corn seeds. (See Part B)

PART A

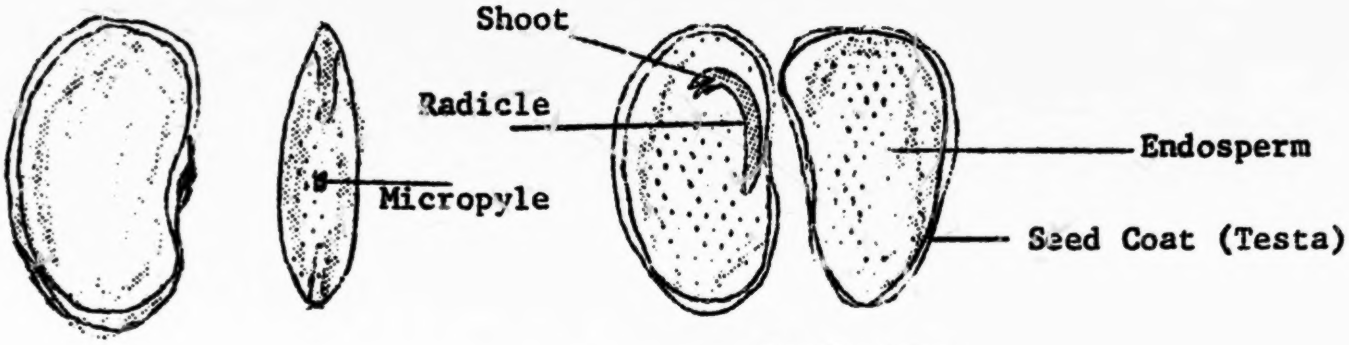
REVIEW

Soak corn seeds and lima bean seeds in water overnight.

Cut a soaked corn seed in half through the middle at right angles to the broad side of the grain. Using a hand lens or stereomicroscope locate the following parts: cotyledon, embryo root, shoot, endosperm. Test part of a corn seed with iodine. What is the color indicator? What compound is present in abundance in the endosperm?



Examine a soaked lima bean and locate the micropyle (small opening through the seed coat.) Of what use is this opening? Cut through the seed coat and separate the two sections of a soaked lima bean. Locate the following parts, using a hand lens or stereomicroscope: cotyledon, embryonic shoot, embryonic leaves, endosperm, embryonic root. Test parts of the bean seed with iodine. What structure in the seed appears to contain the most starch?



Cotyledons

PART B

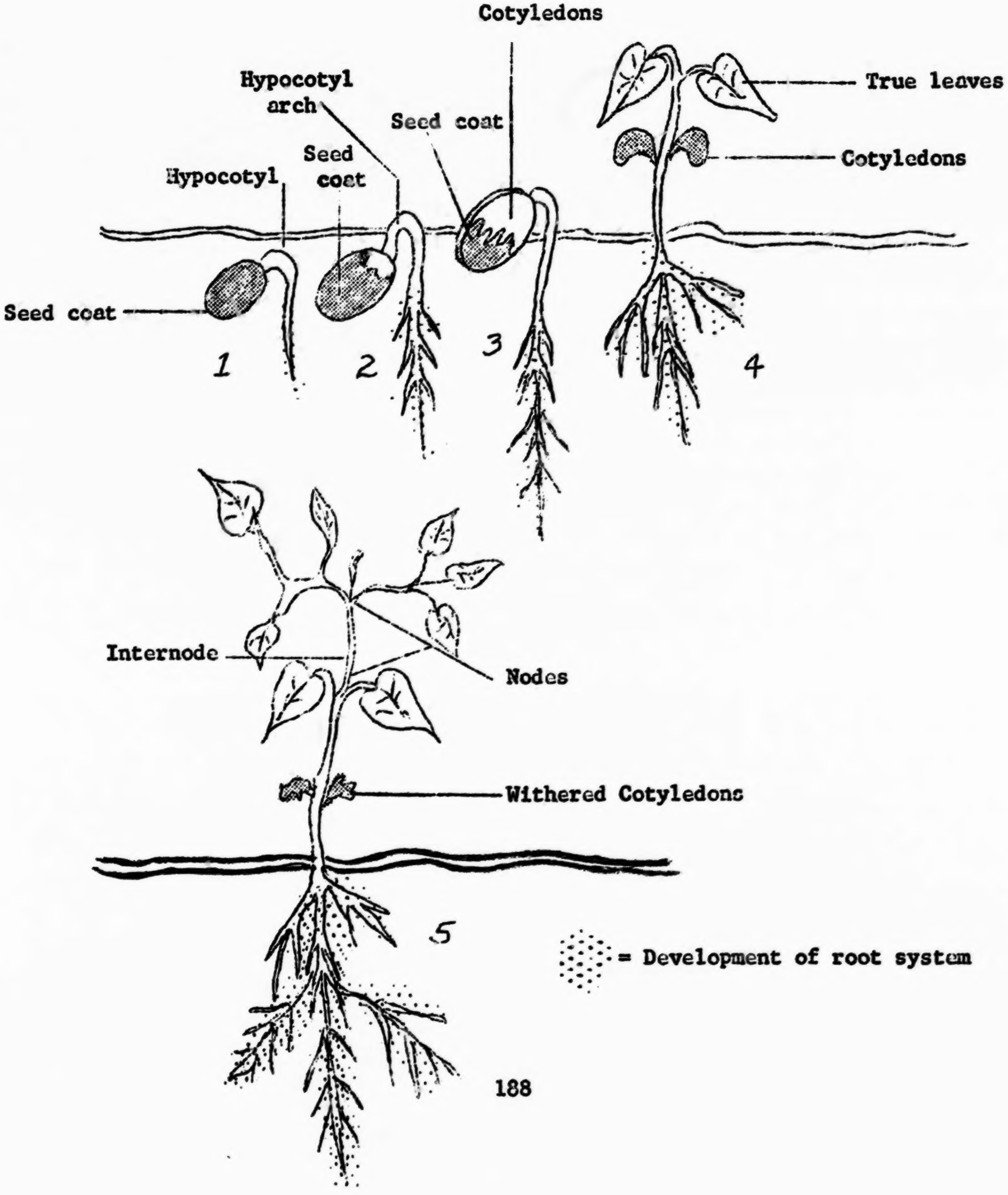
Examine each of five stages in the germination of a bean seed and similar stages in the corn seed.

Locate all the structures in each stage of development of the seedlings. Make sketches of each of the stages of the bean and the corn. Locate the hypocotyl, cotyledons, true leaves, root system, epicotyl, seed coat (testa), node, internode.

What are the major differences in the growth of a corn and a bean seed? How many cotyledons are present in a bean? In a corn? Which organ appears first in the corn? In the bean?
Measure the difference between the cotyledons of a bean seed to the true leaves in the fourth stage and then in the fifth stage. What does this difference in distance suggest about this general area of plant growth?

What is the function of the cotyledons? Why do they disappear?

DEVELOPMENT OF A BEAN SEED


Cotyledons
Hypocotyl arch
Seed coat
Seed coat
Hypocotyl
True leaves
Cotyledons
Seed coat
1
2
3
4
Internode
Nodes
Withered Cotyledons
5
= Development of root system

	LIMA			CORN		
	Absent or Present	No.	Iodine Test	Absent or Present	No.	Iodine Test
Seed Coat						
Cotyledon						
Root Embryo						
Shoot Embryo						
Embryo Leaves						
Endosperm						

Examine a grape, tomato, and apple. Slice each to show the cross sections. Where are the seeds in each example? Examine a pea or bean pod. Open the pod and observe the seeds.

PART C

Examine a sample of a monocot flower and one of a dicot flower. Count the number of petals, sepals, stamens, pistils in each flower. Make a comparison in the chart below.

	MONOCOT	DICOT
Number of sepals		
Number of petals		
Number of stamens		
Number of pistils		

Cut through the ovary of the flower with a razor blade and observe the number of ovules in each. What are the differences between a monocot and dicot in this cross section of an ovary?

UNIT TWO: VARIETY OF LIFE

COMPARISON OF TWO OR MORE KINDS OF PLANTS

PURPOSE

To understand and compare two or more kinds of plants. The more alike two plants are, the more alike their scores will be. The greater the differences between two plants, the greater the differences in their scores will be. Highly developed plants will have a higher score while simple plants will have a low score.

ACTIVITY MATERIALS

- Spirogyra
- Mushroom
- Pine
- Blue-green algae
- Bread mold
- Lichen
- Lily
- Rose
- Moss
- Liverwort
- Fern
- Bacteria
- Other plant varieties
- Ditto copy of key-type score card

WHAT TO DO

*"To determine the score of a particular plant, start at the top of the place marked "START HERE." Lines from this point lead to two choices. Choose the one which fits the plant being scored. Each description on the page, except the last in a line is followed by two lines which lead to two choices. In each case choose the description that best fits the plant being scored, and continue to the end of the line. The total score is the sum of all the numbers appearing in front of the choices used in your journey through the scoring key. In the table of plants scores record the name of each plant, the numerical values of the choices made in scoring it, and the total score."

Make a comparison of five or six plants using the score card. When the score for each of the plants has been established, give each of the plants score a rank. Use one as the rank for the plant with the lowest score and 6 or 10 for the plant with the highest score (6 or 10, if you have scored this number of plants).

---

*High School Biology, Green Version - The Laboratory, Part One, Exercise 4.2, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

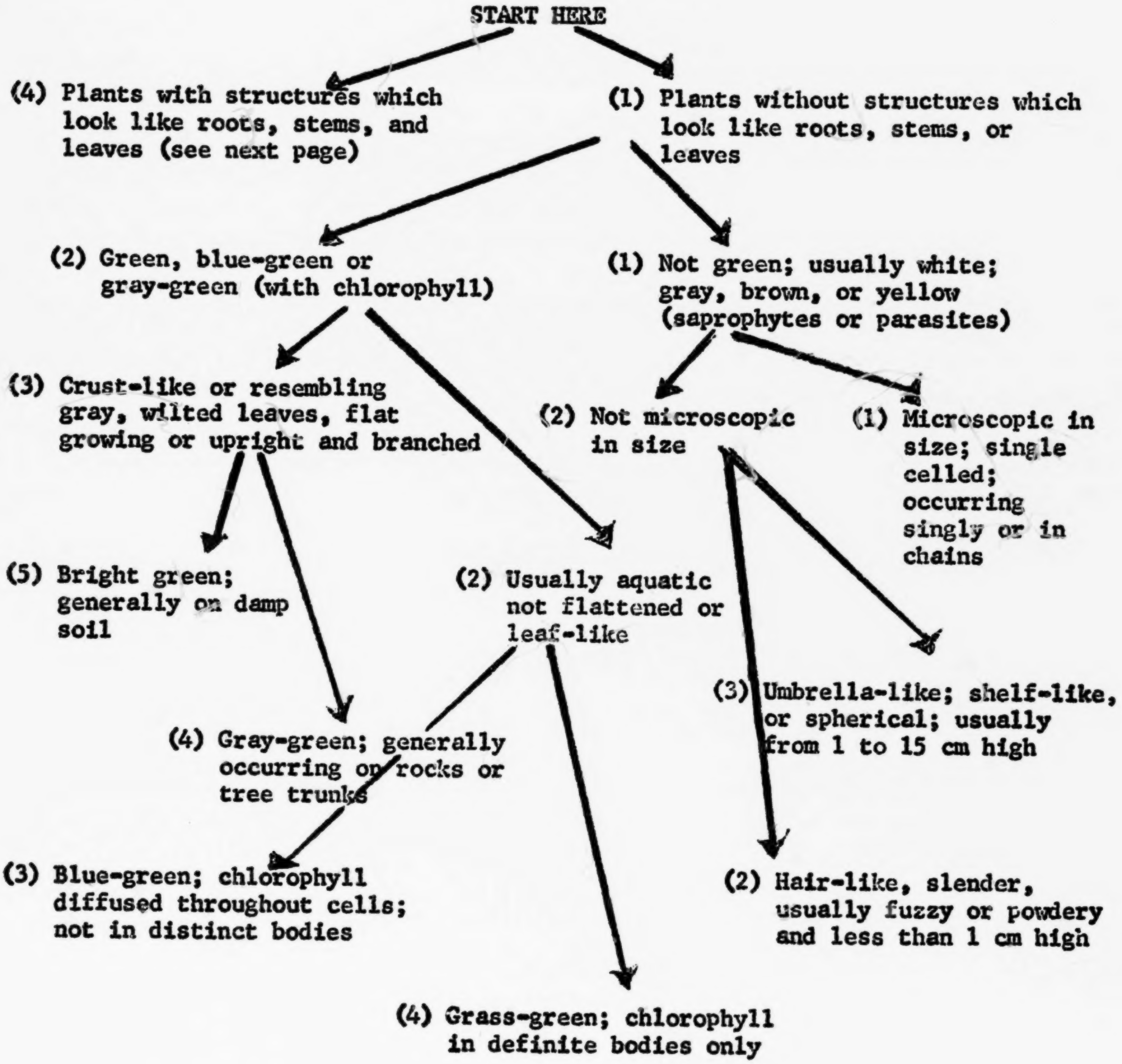
UNIT TWO: VARIETY OF LIFE

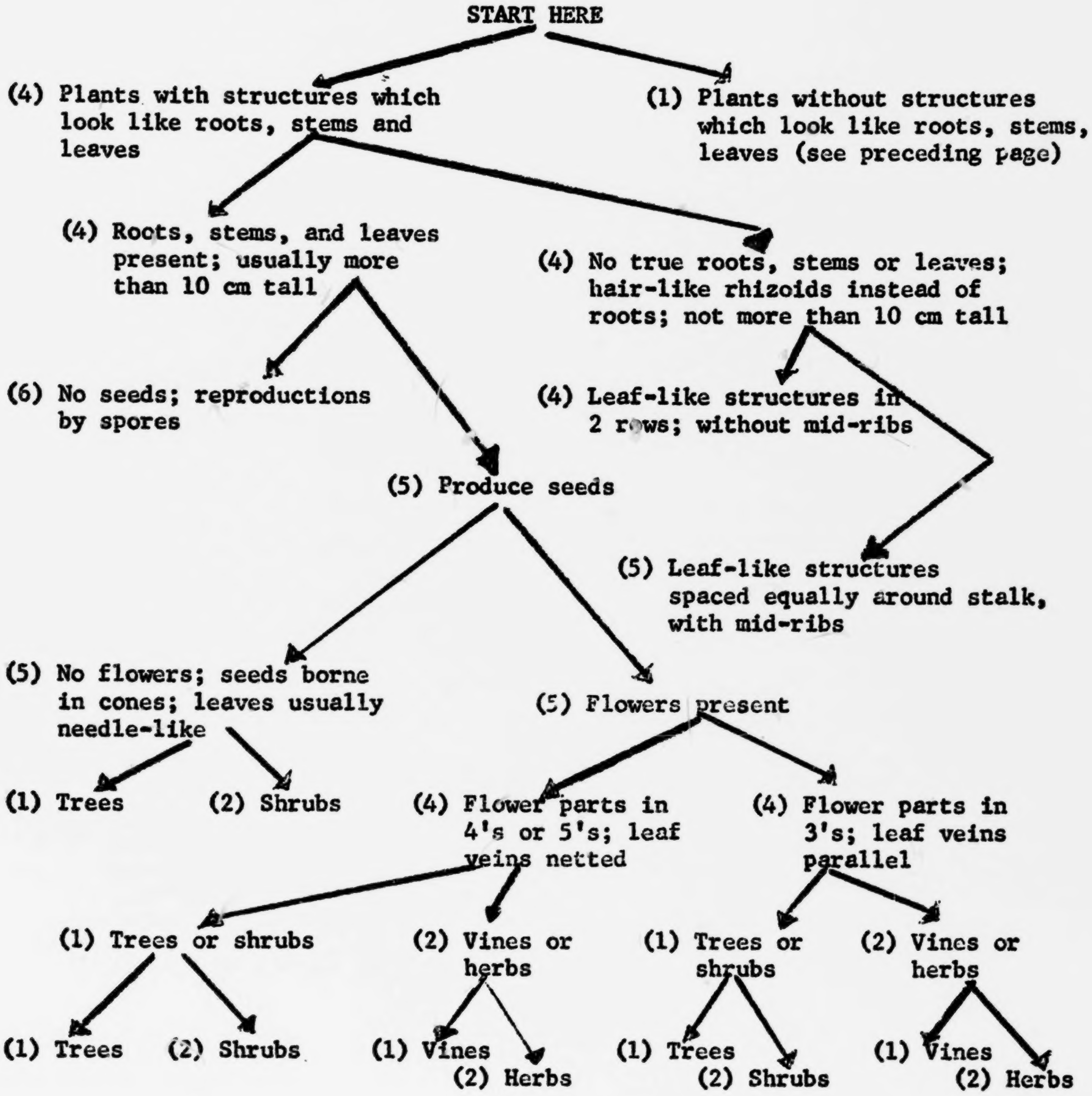
Notice the characteristics of those plants with a rank of 1, 2, 3, and those plants with a rank of 6, 7, 8, and so on.

"Assuming that most existing plants have developed from simpler, fewer, and older species, would you expect plants to show less variety or greater variety as time goes on? Explain.

Basing your conclusions on your use of the plant score card, what do you consider to be some of the major (more important) differences among plants? What are some of the less important differences? On what basis do you distinguish between important differences and less important differences?"

Name of Plant	Numerical Value of Choice Made	Total Score	Rank


START HERE
(4) Plants with structures which look like roots, stems, and leaves (see next page)
(1) Plants without structures which look like roots, stems, or leaves
(2) Green, blue-green or gray-green (with chlorophyll)
(1) Not green; usually white; gray, brown, or yellow (saprophytes or parasites)
(3) Crust-like or resembling gray, wilted leaves, flat growing or upright and branched
(2) Not microscopic in size
(1) Microscopic in size; single celled; occurring singly or in chains
(5) Bright green; generally on damp soil
(2) Usually aquatic not flattened or leaf-like
(3) Umbrella-like; shelf-like, or spherical; usually from 1 to 15 cm high
(4) Gray-green; generally occurring on rocks or tree trunks
(3) Blue-green; chlorophyll diffused throughout cells; not in distinct bodies
(2) Hair-like, slender, usually fuzzy or powdery and less than 1 cm high
(4) Grass-green; chlorophyll in definite bodies only


START HERE
(4) Plants with structures which look like roots, stems and leaves
(1) Plants without structures which look like roots, stems, leaves (see preceding page)
(4) Roots, stems, and leaves present; usually more than 10 cm tall
(4) No true roots, stems or leaves; hair-like rhizoids instead of roots; not more than 10 cm tall
(6) No seeds; reproductions by spores
(4) Leaf-like structures in 2 rows; without mid-ribs
(5) Produce seeds
(5) Leaf-like structures spaced equally around stalk, with mid-ribs
(5) No flowers; seeds borne in cones; leaves usually needle-like
(5) Flowers present
(1) Trees
(2) Shrubs
(4) Flower parts in 4's or 5's; leaf veins netted
(4) Flower parts in 3's; leaf veins parallel
(1) Trees or shrubs
(2) Vines or herbs
(1) Trees or shrubs
(2) Vines or herbs
(1) Trees
(2) Shrubs
(1) Vines
(2) Herbs
(1) Trees
(2) Shrubs
(1) Vines
(2) Herbs

BIOLOGY 1

RESOURCE UNIT

UNIT THREE: DISTRIBUTION OF LIFE

LOS ANGELES CITY SCHOOLS
Curriculum Branch
1963

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UNIT THREE: DISTRIBUTION OF LIFE

USE OF THE RESOURCE UNIT

This resource unit has been prepared and developed for use by biology teachers in Los Angeles City Schools. It is intended that this resource unit be filed in a three-hole loose leaf binder by the teacher. It is hoped that this unbound material will be of greater use to the teacher and will be more adaptable to making changes in sequence and providing for additions and deletions.

The Outline Course of Study for Biology 1, publication SC 597, contains general information vital to the teaching program and should be referred to often. General safety regulations, teaching patterns, and point of view are some of the important sections of this publication. The teacher will find it helpful to use both the Outline Course of Study and the Resource Unit. The Outline Course of Study is available from the Curriculum Branch.

How To Use The Resource Unit

Outline of Content

The teacher should briefly review the pages of this section to receive an over-all view of the entire unit content.

Estimated Time Block

After reviewing the outline of content for this unit, the teacher should make note of the suggested time allotment. The teacher should be encouraged to prepare a block of squares showing the four, five or six week period and plan his own pattern of time allotment for subject matter. The teacher need follow only the estimated time block.

Concepts to Consider

Read the concepts to consider at the beginning of this unit. These concepts are major generalizations of subject content and should serve as guidelines for instruction.

Teaching Approach (Methods and Activities)

The teacher will find this section to be a suggested direction or path for instruction. The approach is sequential and may be used at the discretion of the teacher. It will be noted that there are many more suggestions for teaching than can be carried out for a particular time block. The teacher is charged with the responsibility of selecting those activities best suited to the ability level of his students.

Depth Probe

This section provides three general levels of ability for slow students, average students, and more able students. The teacher may use any or all of these activities. An attempt has been made to alert the teacher to activities that are basic to the subject content. Note that terms such as "optional" or "basic" have been used in this respect. All activities to be done will be decided upon by the individual teacher according to materials and student abilities, regardless of established color code.

"Tools" for Extending Concepts

This section is intended to supply the teacher with enrichment ideas for highly motivated students. Remember that many more ideas have been given than can possibly be carried on, so select those activities that are most suitable.

Planning Ahead

This section is intended to alert the teacher to materials needed for activities coming in following sections of this unit and other units. Pay particular attention to this section in ordering materials from the Science Center, since a two-weeks-in-advance order is necessary for many of the fresh materials.

Broadening "Content Horizons"

This section is divided into three parts. The first part is an area devoted to references to be used by the teacher to gain a broader background for subject content. The second part is an area devoted to references to be used for students, and care has been taken in recommending those books that are generally found in school libraries. The third part is an area devoted to the textbook reading assignments for the particular subject content. The two textbooks cited are Smith, Ella Thea Exploring Biology 4th and 5th Editions; and Moon, Otto, and Towle Modern Biology, 1960 and 1963 Editions.

UNIT THREE: DISTRIBUTION OF LIFE

CONTENT OUTLINE

I. Web of Life

- A. Interdependence of Plants and Animals (Producer, Consumer, and Decomposer)
- B. Food Chains and Pyramids
- C. Cycles (Mineral and Others)
  1. Carbon
  2. Nitrogen
  3. Calcium
  4. Water
  5. CO_2
  6. Others
- D. Man in Nature
  1. Forest Fires and Control
  2. Flood Control
  3. Water Conservation
  4. Animal Conservation (Predator - Prey)
  5. Others (Radiation, Pesticide, Poisons, Drugs, Alcohol, Tobacco)

II. Populations and Communities

- A. Rise and Fall of Populations
- B. Limiting and Balancing Factors
- C. Succession
  1. Plant Populations
  2. Animal Populations

III. Ecological Biogeography

- A. Physical Environment
  - 1. Temperature
  - 2. Oxygen
  - 3. Solar Radiation
  - 4. Others
- B. Biotic Environment
  - 1. Predation
  - 2. Saprobism (Saprophytes, Scavengers, Decomposers)
  - 3. Symbiosis
    - a. Parasitism
    - b. Commensalism
    - c. Mutualism
- C. Principles of Distribution
  - 1. Life Zone Concept (California)
  - 2. Bergman's Law, Allen's Law, etc.
  - 3. Biome(s)
    - a. Freshwater
    - b. Marine
    - c. Forest
    - d. Desert
    - e. Mountains
    - f. Grasslands
  - 4. Biogeographic Realms of the World

UNIT THREE: DISTRIBUTION OF LIFE

TEXTBOOK REFERENCE SUMMARY

Smith, Ella Thea

Exploring Biology   4th Edition

Web of Life	pp. 504-538	
Populations and Communities	pp. 504-538	
Physical Environment	-----------	
Biotic Environment	-----------	See Supplementary Reference Lists
Principles of Distribution	-----------	

Exploring Biology   5th Edition

Web of Life	pp. 603-640	
Populations and Communities	pp. 602-620	
Physical Environment	-----------	See Supplementary Reference Lists
Biotic Environment	-----------	
Principles of Distribution	-----------	

Moon, Otto, and Towle

Modern Biology   1960 Edition

Web of Life	pp. 56-66 and 671-710	
Populations and Communities	pp. 56-66	
Physical Environment	pp. 66-76	See Supplementary Reference Lists
Biotic Environment	pp. 66-76	
Principles of Distribution	pp. 66-76	

Modern Biology   1963 Edition

Web of Life	pp. 56-71 and 671-710	
Populations and Communities	pp. 56-77	
Physical Environment	pp. 66-76	See Supplementary Reference Lists
Biotic Environment	pp. 66-76	
Principles of Distribution	pp. 66-76	

UNIT THREE: DISTRIBUTION OF LIFE

MASTER MATERIALS LIST

EQUIPMENT

Aquaria (8 and 15 gals.)
  converted into terraria
Scale, balance
Stopwatch
World map, wall chart Vegetation Map

SUPPLIES

Non-Consumable

Flannel boards
Mortar and pestle
Ringstands
Scalpels
Scissors

Consumable

Glassware
- Beakers
- Battery jars
- Flasks, Erlenmeyer
- Glass panes
- Glass tubing
- Graduated cylinders
- Petri dishes
- Pipettes (eye dropper type)
- Pipettes (graduated type)
- Slides and cover slips
- Test tubes
- Watch glasses (pyrex)

Chemicals
- Alcohol, Isopropyl 70%
- Brom thymol blue powder
- Carbol fuchsin stain
- Crone's solution
- Diphenylamine
- Distilled water (from demineralizer)
- Peptone
- Potassium monobasic phosphate
- Ringer's solution
- Sodium hypochlorite
- Sulfuric acid

Other Materials
- Aluminum foil
- Box(wood)
- Burette clamps
- Cellophane paper (various colors)
- Construction paper (various colors)
- Cotton
- Cups, paper
- Filter paper
- Forceps
- Funnel
- Graph paper
- Humus
- Paraffin
- Peat moss
- Pebbles (gravel)
- Rhizobium inoculum
- Rocks
- Rubber tubing
- Rubber stoppers (one-hole and two-hole)
- Sawdust
- Seeds, rye, grass, clover, radish, corn, bean, and oats
- Shoe boxes
- Soil, clay, sand, and loam
- String
- Tape, masking
- Towels, paper
- Vaseline
- Vermiculite
- Yarn
- Yeast extract
- Yeast, Fleichman's Dry Active
- Wax marking pencils
- World map study charts for students

LIVING AND FRESH MATERIALS

Branch, leafy woody (freshly picked)
Corn plant (potted)
Cactus plant (potted)
Didinium, pure culture
Daphnis culture
Elodea sprigs
Fernplants, potted and freshly picked
Insectivorous plants
Liverworts (living and preserved)
Molds growing on bread and fruit
Mosses, living and preserved
Mushrooms, freshly picked and dried
  specimens
Paramecium caudatum, pure culture
Pond water
Snails, living
Tradescantia (leafy shoots)
Utricularia, living

UNIT THREE: DISTRIBUTION OF LIFE

ESTIMATED TEACHING TIME: 4 (5) WEEKS

Suggested allotment of time in block below:

Monday	Tuesday	Wednesday	Thursday	Friday	Week
Web of Life	Web of Life	Web of Life	Web of Life	Web of Life	1
Web of Life	Web of Life	Optional	Populations and Communities	Populations and Communities	2
Populations and Communities	Populations and Communities	Populations or Optional	Ecological Biogeography	Ecological Biogeography	3
Ecological Biogeography	Ecological Biogeography	Ecological Biogeography	Ecological Biogeography	Optional	4
					5

UNIT THREE: DISTRIBUTION OF LIFE

CONCEPTS TO CONSIDER

The capture of energy is through photosynthesis by producer organisms (green plants or green protists.)

The greatest mass and energy occur in producers (photosynthetic organisms) and as each step of the food pyramid progresses there is a proportional loss in mass and energy for each succeeding consumer organism.

The sequence of organisms through which materials and energy pass is a food chain.

The many branchings and cross connections among food chains in a biological community is a food web.

The flow of chemicals circulate in characteristic paths from the environment to organisms to environment to organisms over and over again.

Plant and animal communities are interdependent.

When man interferes with the dynamic equilibrium in a natural community, the results may be far-reaching and difficult to correct.

Soil conservation is based on sound ecologic principles; crop rotation, contour farming, the establishing of wind breaks, and the use of proper fertilizers to renew the soil are all measures which maintain a balanced ecosystem.

TEACHING APPROACH (Methods and Activities)

Discuss food chains and food webs

- Demonstrate the interrelations of plants and animals by experiment suggested on pages 204-205.
- Describe food chains through a chalk talk or flannel board cutouts. Some suggested food chains are given on page 206.
- Students should be encouraged to prepare lists of food chains not shown for homework.
- Emphasize words such as "key industry" or "producer organisms," "key industry animals" or "first order organisms," scavenger, decomposer, carnivore, omnivore, herbivore, and others.
- Discuss the relationships of many food chains in a community which result in a food web.
- Students learn about food web concept through laboratory experience suggested on pages 207-208.
- Discuss the effects of removing one organism from a food web, as may be demonstrated in laboratory experience suggested above. Students list organisms that are directly affected and those that are indirectly affected.

- Discuss the concept of a food pyramid. Prepare a flannel board demonstration to illustrate food pyramids in a pond, ocean, and others. Discuss the correlation of food pyramid with the pyramid of numbers, and the pyramid of mass. See page 209.

Discuss cycles and their relationships with the biotic environment.

- Students aid in listing various mineral cycles on the board.
- Discuss the carbon and oxygen cycles. Use chalk board diagrams or flannel board cutouts to help understandings.
- Prepare ditto sheets of experiment on pages 212-213. Allow students to complete the ditto sheet describing the cycles. Discuss questions to be answered on this experiment after assignment has been completed.
- Discuss the nitrogen cycle. Use chalk board diagrams or flannel board cutouts to help student's understanding.
- Prepare ditto sheets of experiment on pages 214-215. Allow students to complete the ditto sheet describing the cycle. Discuss questions to be answered on this experiment after assignment has been completed.
- Students test various soils to discover the presence of nitrogen. See pages 217-218.
- Assign some students reports on nitrogen-fixing bacteria, and denitrifying bacteria.
- Discuss the calcium cycle. Use the chalk board or flannel board cutouts to help student understanding.
- Prepare a ditto sheet of the calcium cycle. Allow students to complete ditto sheet describing the cycle. Discuss questions to be answered on this experiment after assignment has been completed.
- Discuss the water cycle. Demonstrate condensation by boiling muddy water and collecting water vapor in a cold container. Students will see that drops are clear and free of dirt.
- Prepare a ditto sheet which illustrates the main elements of the water cycle. Students label and correlate various sections of the ditto sheet for added information. See page 216. Discuss "seeding" clouds.

Discuss man as a force in the environment

- Assign students to survey the watershed areas located in Southern California.
- Discuss the importance of the watershed to our area.
- Discuss the importance of the water problem in Southern California.
- Students report on how Southern California is supplied with water.
- Students prepare a map of Los Angeles County, to show watershed cover, rivers, lakes, streams, water reservoirs, aqueducts, and others.

- Discuss forest fires and their control. Have students read Scientific American reprint by Charles Cooper, "Ecology of Fire" (April, 1961).
- Students should use experiment on pages 219-221, as a study guide to help in understanding articles suggested above.
- Students prepare a map of the Los Angeles County (or Southern California area) to show forest fire areas in the last five years. Students should be able to correlate these with flood areas during rainy seasons for the past five years.
- Discuss erosion, such as raindrop erosion, wind erosion, and others. Encourage some students to take photographs of areas near where they live which show erosion. Display pictures on the bulletin board.
- Demonstrate the need for soil conservation by experiments suggested on pages 222-223.
- Discuss preventive measures used in soil conservation. Illustrate these measures by experiments on pages 222-223.
- Encourage students to bring in various rocks covered with lichen or moss. Have them notice how easily the rock crumbles. What is the cause of this?
- Discuss soil profiles. A suggested profile is given on page 224. Point out from this study of a soil profile that hundreds of years were required for an inch of soil to form from eroded rock and organic matter.
- Students make tests of various soils for water retention, soil acidity and others during another topic of this unit and a correlation of these can be made at a later time to show relationships to soil erosion.
- Discuss animal conservation practices. Students may report on fish and game laws.
- Students make lists of wildlife found in Southern California.
- Prepare a map of Los Angeles County, showing the wildlife areas, forest areas.
- Prepare a map of California to show the forest areas. National Parks, and others.
- Discuss the effects of pesticides, radiation, and others in the web of life.
- Discuss the harmful effects of alcohol, narcotics, and tobacco on populations.

DEPTH PROBE

- INTERRELATEDNESS OF PLANTS AND ANIMALS, pp. 204-205 (Average Student Basic Activity)--To understand and learn about the relationships between plants and animals in a sealed environment. Students work in pairs or groups.

- FOOD CHAIN, p. 206 (Average Student Basic Activity)--To understand the general pattern of a food chain. Teacher demonstration.

UNIT THREE: DISTRIBUTION OF LIFE

- ILLUSTRATION OF A FOOD WEB, pp. 207-208 (Average Student Basic Activity)--To understand and learn about the complex relationships that exist in a food web. Students work in groups.
- FOOD PYRAMID, p. 209 (Average Student Basic Activity)--To understand the concept of a food pyramid. Teacher demonstration.
- FOOD RELATIONSHIPS IN A FRESH-WATER POND, pp. 210-211 (More Able Student Basic Activity)--To understand the concept of food chains and cycles of organic compounds into inorganic compounds and back again. Students work individually.
- CARBON AND OXYGEN CYCLES, pp. 212-213 (Average Student Basic Activity)--To learn the pathways of carbon and oxygen and the relationships of organisms and processes. Students work individually.
- NITROGEN CYCLE, pp. 214-215 (Average Student Basic Activity)--To learn the pathways in the nitrogen cycle and the relationships of organisms and processes. Students work individually.
- WATER CYCLE, p. 216 (Average Student Basic Activity)--To understand and learn the pathways of the water cycle and its relation to the distribution of living things. Students work individually or teacher demonstration.
- NITROGEN IN THE SOIL, pp. 217-218 (Average Student Basic Activity--Optional)--To understand that nitrogen is found in soil in the form of nitrates. Students work in teams.
- FOREST FIRES, pp. 219-221 (Average Student Basic Activity)--To learn and understand the need for fire prevention and control in forested areas of our community. Students work individually as homework assignment.
- EFFECT OF TERRACING, p. 222 (Slow Learner Student Basic Activity)--A visual method to demonstrate the effect of terracing in soil conservation. Teacher demonstration.
- EROSION AND THE SLOPE OF THE LAND, p. 223 (Average Student Basic Activity--Optional)--To understand the mechanics of good soil conservation practices and the need for such practices. Students work in groups.
- SOIL PROFILE, p. 224 (More Able Student Basic Activity--Optional)--To understand the make-up of soil through a profile study. Teacher demonstration or student demonstration.
- NATURE'S HOUSE THAT JACK BUILT, p. 225 (Slow Learner Student Basic Activity)--An illustration of a flannel board demonstration or bulletin board design. Teacher demonstration.

"TOOLS" FOR EXTENDING CONCEPTS

- Plan to show filmstrips
    "Conservation of Redwood Region Forests," Set 1, H-2
    "Conservation is Everybody's Business," Set 1, S-82
    "Soil Conservation," Set 1 through 8, S-70
    "Water Purification," Set 1, S-92
    "Introduction to Insects," No. 22 - Sound Filmstrip

- Display pictures of soil conservation, water conservation, and wildlife conservation on bulletin board. Order sets of pictures:

"Soil Conservation,"	Set 1, and Set 2,	S-19
"Water Conservation,"	Set 9, and Set 10,	S-10
"Wildlife Conservation,"	Set 1,	S-21

- Plan to show films

"Life in a Pond,"	Fsd 591.92-9
"Life in the Sea,"	Fsd 591.92-23
"The Eternal Cycle,"	Fsd 574.191-1
"The Chain of Life,"	Fsd 574.5-1
"Watershed Fire,"	Fsd 614.84-4

- Prepare a bulletin board display to emphasize the need for conservation.
- Encourage some students to visit the water department and give a report of their field trip.
- Assign students to report on past, present, and future demands for water in Southern California.
- Encourage students to do research on food webs other than those studied in class. Students may make posters or prepare bulletin board displays of their work.
- Assign student reports on forestry practices used in our national parks.
- Prepare a bulletin board display of the various fish and game laws and conservation laws all citizens should know.
- Encourage some student to make a study of the types of soil found in Southern California.
- Assign some student a report on the effect of Strontium-90 in the calcium cycle.
- Encourage students to do research on the effects of pesticides in food webs.
- Assign students the task of making drawings and sketches of living organisms in a fresh-water pond study.

- Assign students to do research on the effect of radiation on seeds and other organisms.
- Encourage students to prepare a map of the United States to show National Park areas, Forest areas, and others.
- Assign students to prepare a bulletin board display on a map of California to show wildlife areas with distinctive animals of each area.
- Encourage some students to do research work on the effect of raindrop erosion. Suggestions for doing this research work are found on page 239 in A Sourcebook for the Biological Sciences, by Morholt, Brandwein, and Joseph. New York: Harcourt, and Brace, 1958.
- Assign some students to make a study of the temperature of soils in different areas of the school grounds.
- Encourage students to investigate the school campus and decide whether any areas of the campus are beginning to show soil erosion. Students may also make recommendations for conservation measures.
- Assign students to report on the animals in Southern California that still call for a bounty. Students may want to investigate those animals that no longer bring in a bounty. Make lists and report to the class on their findings.
- Encourage some students to visit the county agricultural agent to find out about conservation practices in our area.
- Plan a field trip to a nearby water purification plant.

PLANNING AHEAD

- Prepare ditto sheets of semi-log paper for experiment on page 239.
- Locate and reserve chemicals such as yeast extract, potassium phosphate (monobasic), distilled water, glucose, peptone, dry active yeast, and others.
- Review procedure for making dilutions and cell counts.
- Gain background on population studies and population curves.
- Review information on graph making. Give examples of bar graph, line graph, and so on.
- Prepare a bulletin board display entitled SUCCESSION
- Locate a class set of atlases for experiment on page 333. (Check with textbook clerk)
- Locate and reserve several books, such as How to Know the Protozoa, How to Know Fresh-Water Algae. (See page 178 for bibliography for other selections).
- Plan with student teams to do an ecological survey of a particular area of the campus.

- Assign students to bring in leaves from their backyard or front lawn for experiment on page 224.
- Store pond water for experiment on page 246.
- Prepare flannel board cutouts for demonstration on a pond succession as suggested on page 248
- Make a collection of various pictures of plants and animals for biome displays.
- Locate and store a large number of test tubes for population study.
- Encourage some students to plan a field trip to the seashore to make collections and give a report of field trip.
- Prepare directions on building of dioramas for biome displays as suggested in appendix. See page 322.
- Plan to order materials for terrarium habitats as suggested on pages 322 and 323.
- Cut aluminum foil into squares as covers for test tubes in population study. See page 235.
- Prepare a bulletin board display or flannel board demonstration on succession in a microenvironment as suggested on page 246.
- Make a plan of the school campus with signs indicating the route to be followed and other signs indicating temperature, humidity, and so on, for a field trip during the class period.
- Prepare a list of plants (and animals) found on the school campus for use on field trip.
- Order and store maps of the world and the United States for work in ecological biogeography.
- Reserve books in the library on ecological biogeography.

BROADENING "CONTENT HORIZONS"

Teacher References:

Articles from Scientific American

Ellison, W. D. "Erosion by Raindrop," (November, 1948)
Sayre, A. N. "Ground Water," (November, 1950)
Kellogg, Charles. "Soil," (July, 1950)
Plass, Gilbert. "Carbon Dioxide and Climate," (July, 1959)
Went, Frits. "Climate and Agriculture," (June, 1957)
Smith, R. F., and W. Allen. "Insect Control and the Balance in Nature," (June, 1954)

Milne, Lorus and Margery. The Balance of Nature. New York: Knopf, 1960.

UNIT THREE: DISTRIBUTION OF LIFE

United States Department of Agriculture Yearbooks, Washington, D. C.

- Soils and Man, 1938
- Farmers in a Changing World, 1940
- Climate and Man, 1941
- Water, 1955
- Land, 1958

Dasmann, Raymond. Environmental Conservation. New York: Wiley, 1959.

Bennett, H. H. Elements of Soil Conservation. New York: McGraw-Hill, 1947.

Leopold, A. Game Management. New York: Scribner's Sons, 1933.

National Education Association. Conservation Education in American Schools. Yearbook of the American Association of School Administrators, 1951. Washington, D. C.

Student References:

Articles from Scientific American suggested above

Peterson, Elmer. Big Dam Foolishness. New York: Devin-Adair, 1954.

Buchsbaum, Ralph and Mildred. Basic Ecology. Pittsburgh, Pa.: Boxwood Press, 1957.

Odum, Eugene. Fundamentals of Ecology, 2nd Edition. Philadelphia: Saunders, 1961.

Storer, John. Web of Life. New York: Devin-Adair, 1961.

Milne, Lorus and Margery. The Biotic World and Man. Englewood Cliffs, New Jersey: Prentice-Hall, 1958.

Simpson, G., et al. Life: An Introduction to Biology. New York: Harcourt, and Brace, 1957. (Title III - Collection)

Benton, Allen, and W. E. Werner. Principles of Field Biology and Ecology. New York: McGraw-Hill, 1958. (Title III - Collection)

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Osborn, F. Our Plundered Planet. Boston: Little, Brown, Co., 1948.

Elliott, Charles, (Editor). Fading Trails, The Story of Endangered American Wildlife. New York: Macmillan Co., 1942.

Graham, Edward. Natural Principles of Land Use. New York: Oxford University Press, 1944.

Harrison, G. R. What Man May Be, The Human Side of Science. Morrow, 1956.

Government Publications, Superintendent of Documents, Government Printing Office, Washington, D. C.

Know Your Watersheds. U. S. Forest Service. 1948.

Making Land Produce Useful Wildlife. U. S. D. A., Farmer's Bulletin #2035, 1951.

Youth Can Help Conserve These Resources--Soil, Water, Woodland, Wildlife, and Grass. Soil Conservation Service, U. S. D. A., Information Bulletin #52, 1951.

Holbrook, Stewart. Burning an Empire. New York: Macmillan, 1943.

Pinchot, Gifford. Breaking New Ground. New York: Harcourt, and Brace, 1957.

Textbook References:

Smith, Ella Thea. Exploring Biology, 5th Edition. pp. 603-640.

Moon, Otto, and Towle. Modern Biology. pp. 56-76 and 671-710.

UNIT THREE DISTRIBUTION OF LIFE

INTERRELATEDNESS OF PLANTS AND ANIMALS

PURPOSE

To understand and learn about the relationships between plants and animals in a sealed environment

ACTIVITY MATERIALS

Test tubes
Brom thymol blue solution
Snails
Elodea sprigs
Rubber or cork stoppers
Paraffin
Pond water
Wax marking pencil

WHAT TO DO

In each of four test tubes put in clear pond or aquarium water until the bottom portion of the test tube is about half full. Add 3-5 drops of brom thymol blue solution to each test tube. Label the test tubes #1, #2, #3, and #4. To tube #1 do not add anything; to tube #2 add a snail; to tube #3 add a sprig of Elodea; to tube #4 add a snail and a sprig of Elodea. Put a cork or rubber stopper in each of the four test tubes and seal each with melted paraffin. Make observations each morning and each afternoon. Record any changes noticed in the color of the water, location of the color change, and the condition of the plants and animals. (Figure 1)

What is meant by a "control"? Which test tube is the "control"? Can organisms in this experiment survive without an outside supply of air? What is the function of the brom thymol blue solution in each test tube? Can animals survive a sealed community without plants? Can plants survive a sealed community without animals? Why? Why not? Why is it better to use pond water instead of distilled or tap water in this experiment? Information should be recorded in chart. (Figure 2)

Taken from High School Biology, Green Version - The Laboratory, Part One, Exercise 1.2, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

Morholt, E. Experiences in Biology, A Laboratory Manual and Workbook. New York: Harcourt, Brace and Co., 1960. pp. 264-265. (A good reference)

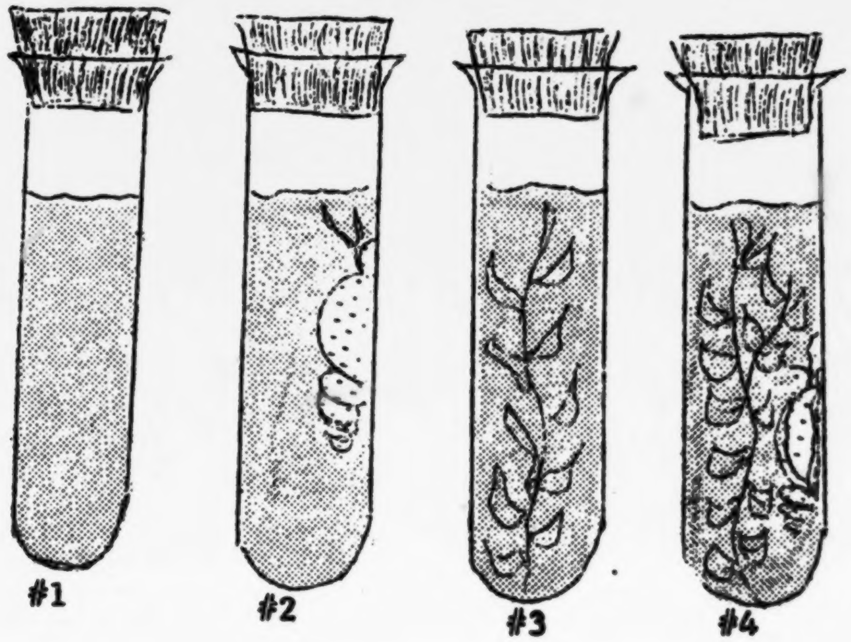


Figure 1

		Time & Date	Time & Date	Time & Date	Time & Date
Tube #1	a.m.				
	p.m.				
Tube #2	a.m.				
	p.m.				
Tube #3	a.m.				
	p.m.				
Tube #4	a.m.				
	p.m.				

Figure 2

FOOD CHAIN

PURPOSE

To understand the general pattern of a food chain

ACTIVITY MATERIALS

Flannel board cutouts of designs below

WHAT TO DO

Prepare cutouts of several food chains and through the use of these cutouts on the flannel board students will learn some important terms such as, "key industry organism," "key industry animal," carnivorous animal, scavenger, (carnivore, omnivore, herbivore) decomposer organism, and others.

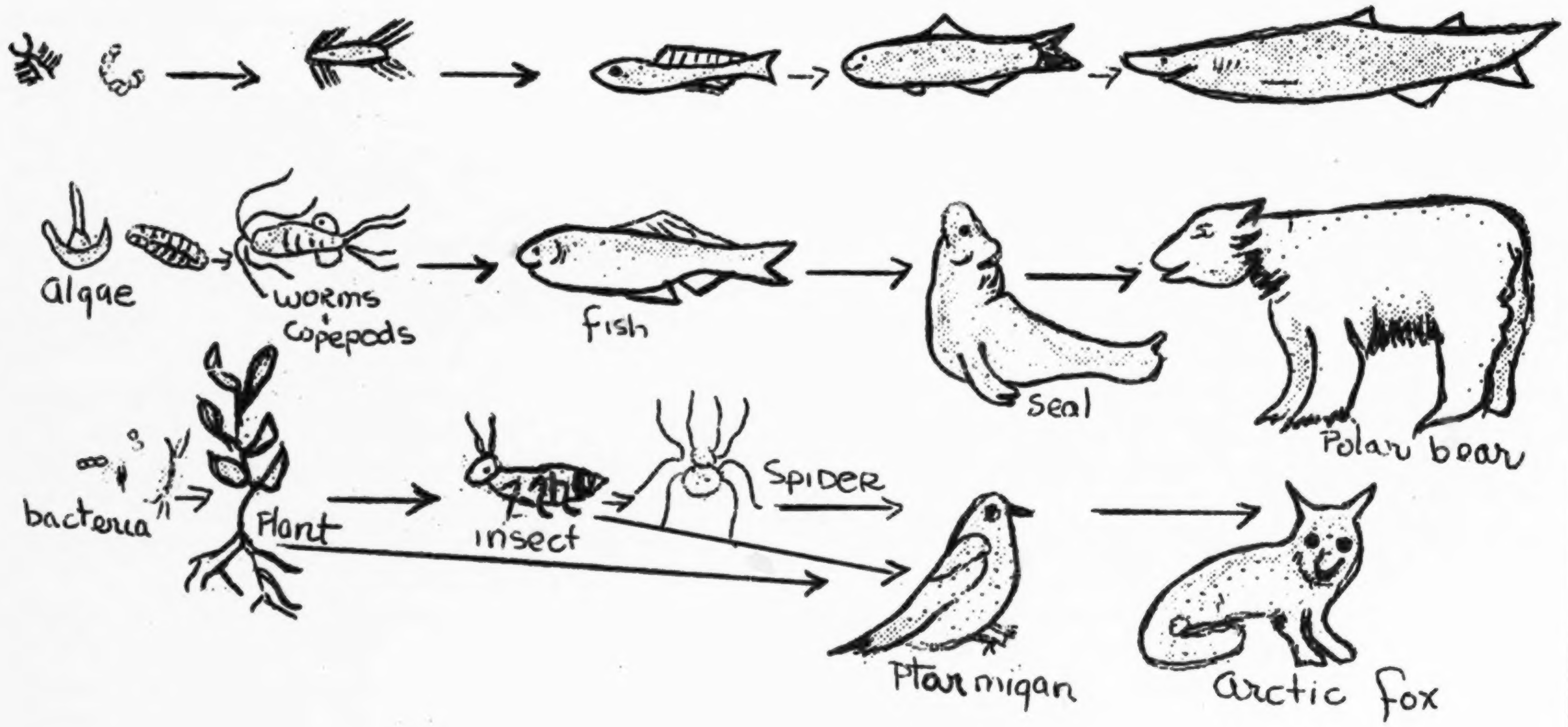

algae
worms
copepods
fish
seal
Polar bear
bacteria
Plant
insect
Spider
Ptarmigan
arctic fox

ILLUSTRATION OF A FOOD WEB

PURPOSE

To understand and learn about the complex relationships that exist in a food web

ACTIVITY MATERIALS

String or yarn in different colors
Paper labels

WHAT TO DO

Use a marking pen (felt nib) or pencil to make paper signs of all species within a biome. If Beech-Maple biome is used, for example, signs such as maple, beech, snails, deer, squirrels, foxes, insects, rabbits, mushroom, algae, ivy, berry vines, mosses, flicker, wood frogs, lichen, and liverworts.

Choose one student and pin to his back the sign "beech tree." Choose another and mark him "squirrel." Evoke from the class whether there is any relation between the tree and the squirrel. Students will suggest many ideas, such as squirrel nests in tree, or that the squirrel gets food from the nuts. Show this connection or relation by tying a string between the "squirrel" and the "beech tree."

Label another student "fox," another "rabbit," and repeat above questioning. Tie string from fox to rabbit because fox may eat rabbit. Repeat with (Flicker) bird to tree, bird to insect, insect to green plant, and to tree, deer to moss, and other green plants, snail to green plants, frog to insect and so on. Gradually there will be built up a complicated web of relationships such as that which exists in actual life.

What would happen if one animal or plant was removed from the food web? Show by breaking the string connections. Students will see that many lines of the relationship are broken.

From this exercise students should be able to establish and trace several food chains. Assign this as written homework assignment.

Adapted from Ella Thea Smith, Exploring Biology, 5th Edition, Teacher's Manual (New York: Harcourt, Brace, and World, 1961), pp. 245-246. Permission granted by publishers.

ALTERNATE METHOD

Follow the same method described in the first paragraph on page 207 for making signs on Beech-Maple biome.

Students are selected to choose a particular sign or cutout of plant or animal. Student decides what kind of relationship he has between other organisms by attaching his string or yarn to one or several other organisms. All students chosen for the food web should find some point of attachment to another "organism." This places the burden upon the students and their background information learned previous to this lesson.

FOOD PYRAMID

PURPOSE

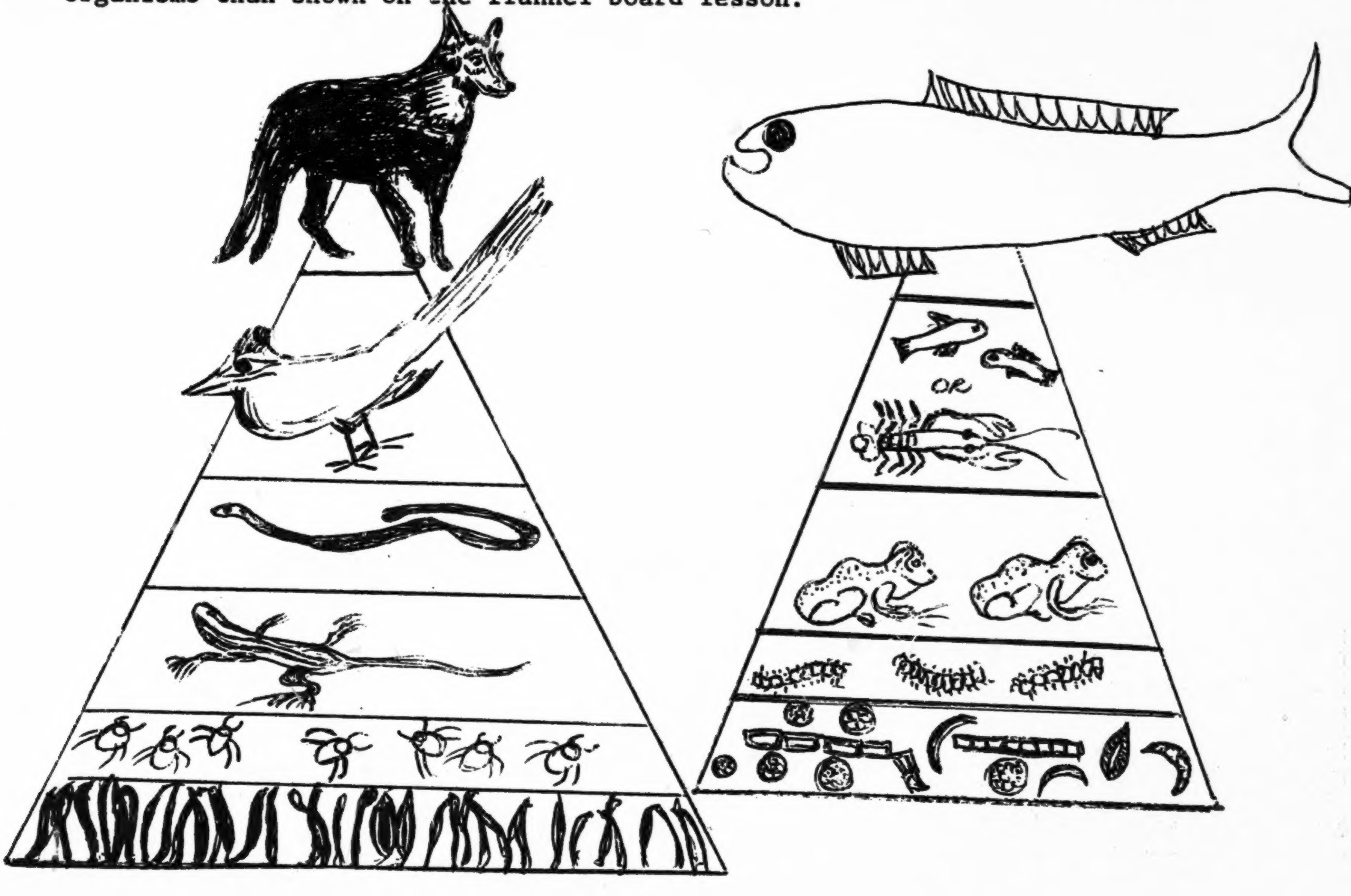
To understand the concept of a food pyramid.

ACTIVITY MATERIALS

Poster of food pyramid or flannel board cutouts of pyramid
Ditto sheet with food pyramid blank

WHAT TO DO

Give an explanation of a food pyramid by building a pyramid on the blackboard as a chalk-talk or on the flannel board with cutouts. Students are given a homework assignment to fill in food pyramid ditto sheet with other types of organisms than shown on the flannel board lesson.



FOOD RELATIONSHIPS IN A FRESH-WATER POND

PURPOSE

To understand the concept of food chains and cycles of organic compounds into inorganic compounds and back again.

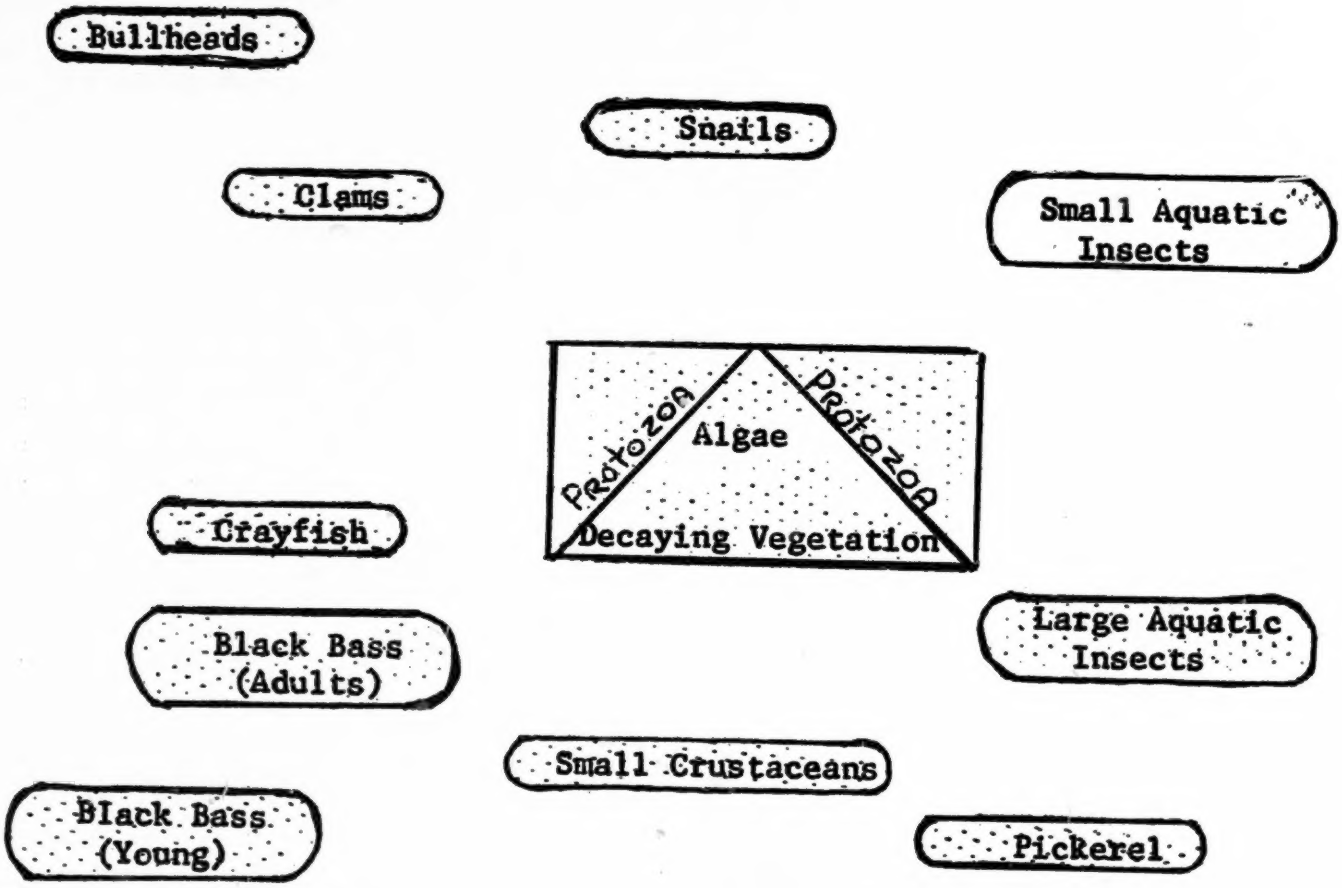
ACTIVITY MATERIALS

Ditto diagram of pond relationships for each student and questions to be answered about the diagram

WHAT TO DO

Give each student a ditto diagram to be completed on the food chains in a fresh-water pond. This may be given as a homework assignment or it may accompany a chalk talk or flannel board lesson on food cycles.

Ditto Sheet - Figure 1


Bullheads
Snails
Clams
Small Aquatic Insects
Protozoa
Protozoa
Algae
Decaying Vegetation
Crayfish
Black Bass (Adults)
Large Aquatic Insects
Small Crustaceans
Black Bass (Young)
Pickerel

Adapted from Lawson, Chester, et al. Laboratory Studies in Biology. San Francisco: Freeman Co., 1958. pp. 315.

Complete the diagram given on page 210. Arrows pointing from the organisms to other organisms indicate organisms eaten by those doing the eating.

Which type of organism is capable of converting inorganic compounds into organic compounds?

Which organism is considered to be a "key industry" organism? What energy foods are manufactured by these organisms? What is the source of nitrogen in this food chain? Which animal in this relationship is a "key industry" animal? Which of the animals are carnivorous? Which organisms are able to convert the nitrogen into a form which can be utilized by other organisms?

CARBON AND OXYGEN CYCLES

PURPOSE

To learn the pathways of carbon and oxygen and the relationships of organisms and processes

ACTIVITY MATERIALS

Flannel board cutouts or chalk talk diagrams
Ditto sheets for each student of material listed below. See page 213.
Reference materials and textbook information

WHAT TO DO

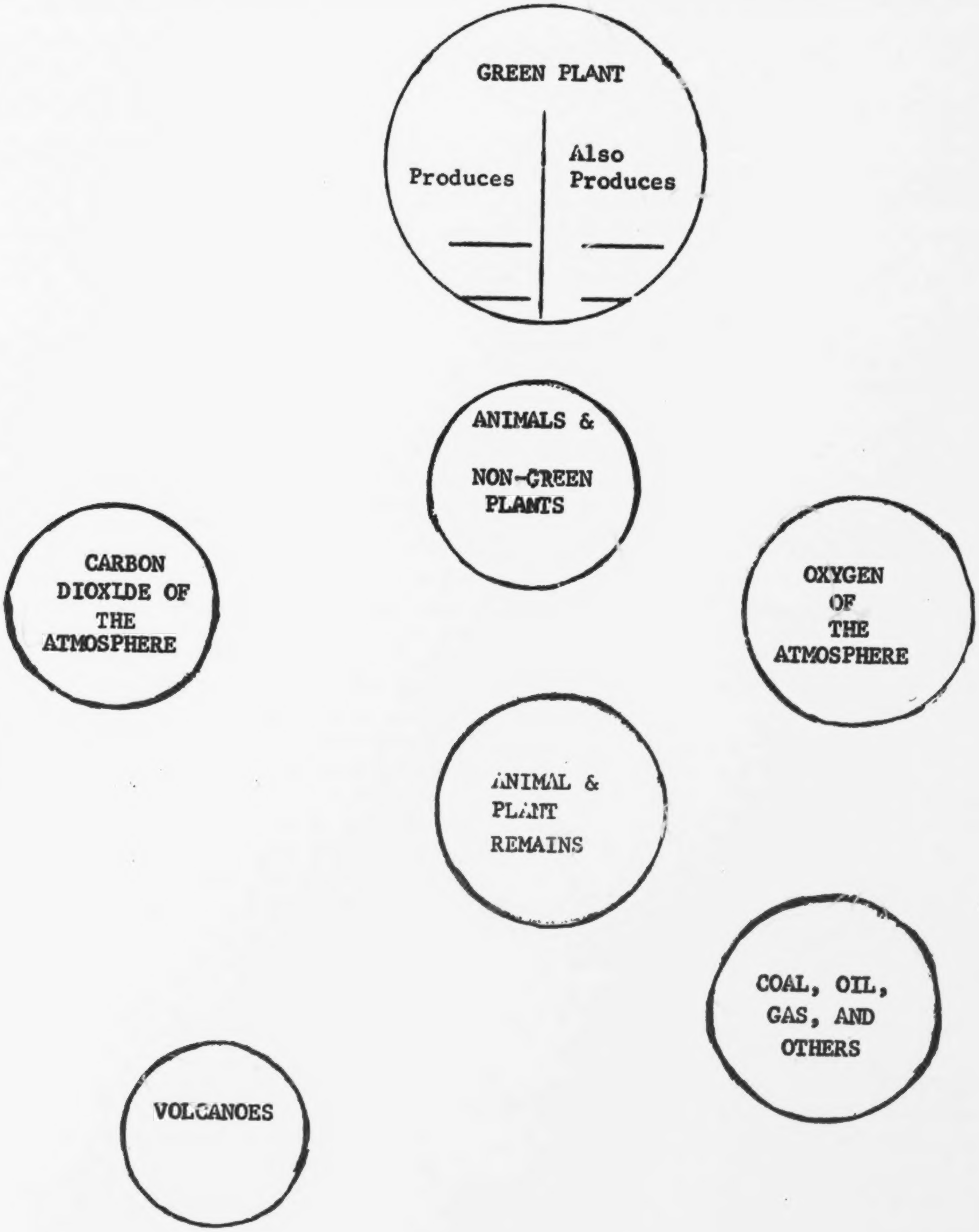
With flannel board cutouts or a chalk talk diagram, give a brief explanation of carbon and oxygen cycles. Give reference information and related textbook reading. Pass out the following ditto sheet to each student (see page 213).

Directions: Complete the following diagram (figure 1) indicating relationships with arrows (label each arrow with the name of the process involved) and also fill in the blanks in the circles. Use a blue line for oxygen cycle and a black line for the carbon dioxide cycle.

How many arrows do you have between the carbon dioxide of the atmosphere and the green plant? What is the source of carbon? In what form is carbon found in the atmosphere? What is the process whereby inorganic carbon is converted into the carbon of an organic compound? In what chemical form is carbon that is used by living things? What kind of organisms use oxygen and give off carbon dioxide? What non-biological processes release carbon dioxide into the atmosphere? In what process is oxygen released into the atmosphere? In what process is carbon returned to the atmosphere?

Adapted from Lawson, Chester, et al. Laboratory Studies in Biology. San Francisco: Freeman Co., 1958. pp. 310-311.

UNIT THREE: DISTRIBUTION OF LIFE


GREEN PLANT
Produces
Also Produces
ANIMALS & NON-GREEN PLANTS
CARBON DIOXIDE OF THE ATMOSPHERE
OXYGEN OF THE ATMOSPHERE
ANIMAL & PLANT REMAINS
COAL, OIL, GAS, AND OTHERS
VOLCANOES

NITROGEN CYCLE

PURPOSE

To learn the pathways in the nitrogen cycle and the relationships of organisms and processes

ACTIVITY MATERIALS

Flannel board cutouts or chalk talk diagrams
Ditto sheets for each student of material listed below
Reference materials and textbook information

WHAT TO DO

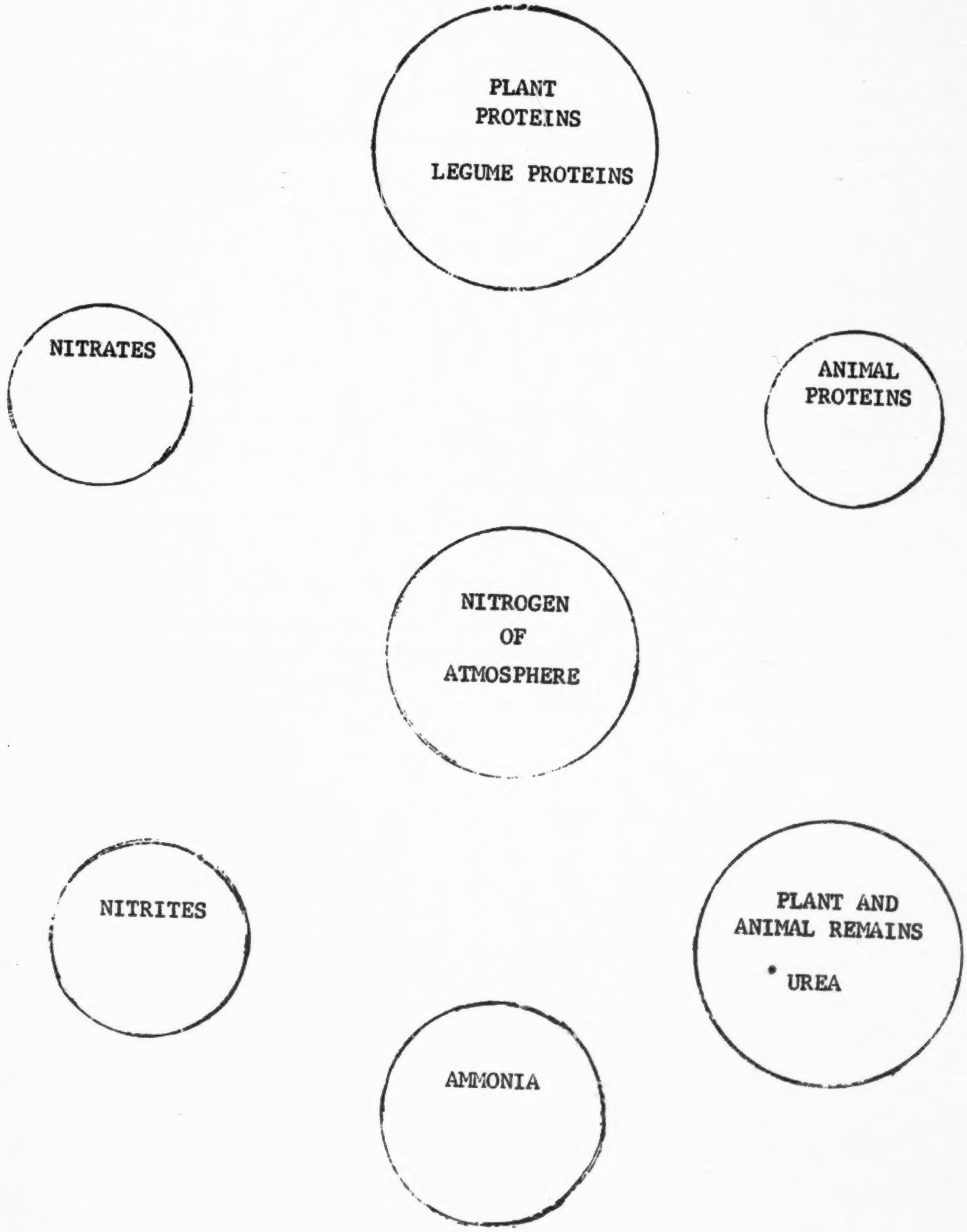
With flannel board cutouts or a chalk talk diagram, give a brief explanation of the nitrogen cycle. Give reference information and related textbook reading. Pass out the following ditto sheet to each student to complete.

Directions: Complete the following diagram (Figure 1) below, indicating relationships with arrows, and labeling the organisms and processes involved.

What causes the combination of nitrogen gas into nitrates and nitrites? What happens to the Urea in the soil? Do plants take in nitrogen gas as a raw material? If not, why not? What are the functions of Nitrosomas and Nitrobacter bacteria? What causes decay of organic matter? What is given off during this decomposition period?

References:

Lawson, Chester, et al. Laboratory Studies in Biology. San Francisco: Freeman Co., 1958. pp. 312-313.


PLANT PROTEINS
LEGUME PROTEINS
NITRATES
ANIMAL PROTEINS
NITROGEN OF ATMOSPHERE
NITRITES
PLANT AND ANIMAL REMAINS
• UREA
AMMONIA

WATER CYCLE

PURPOSE

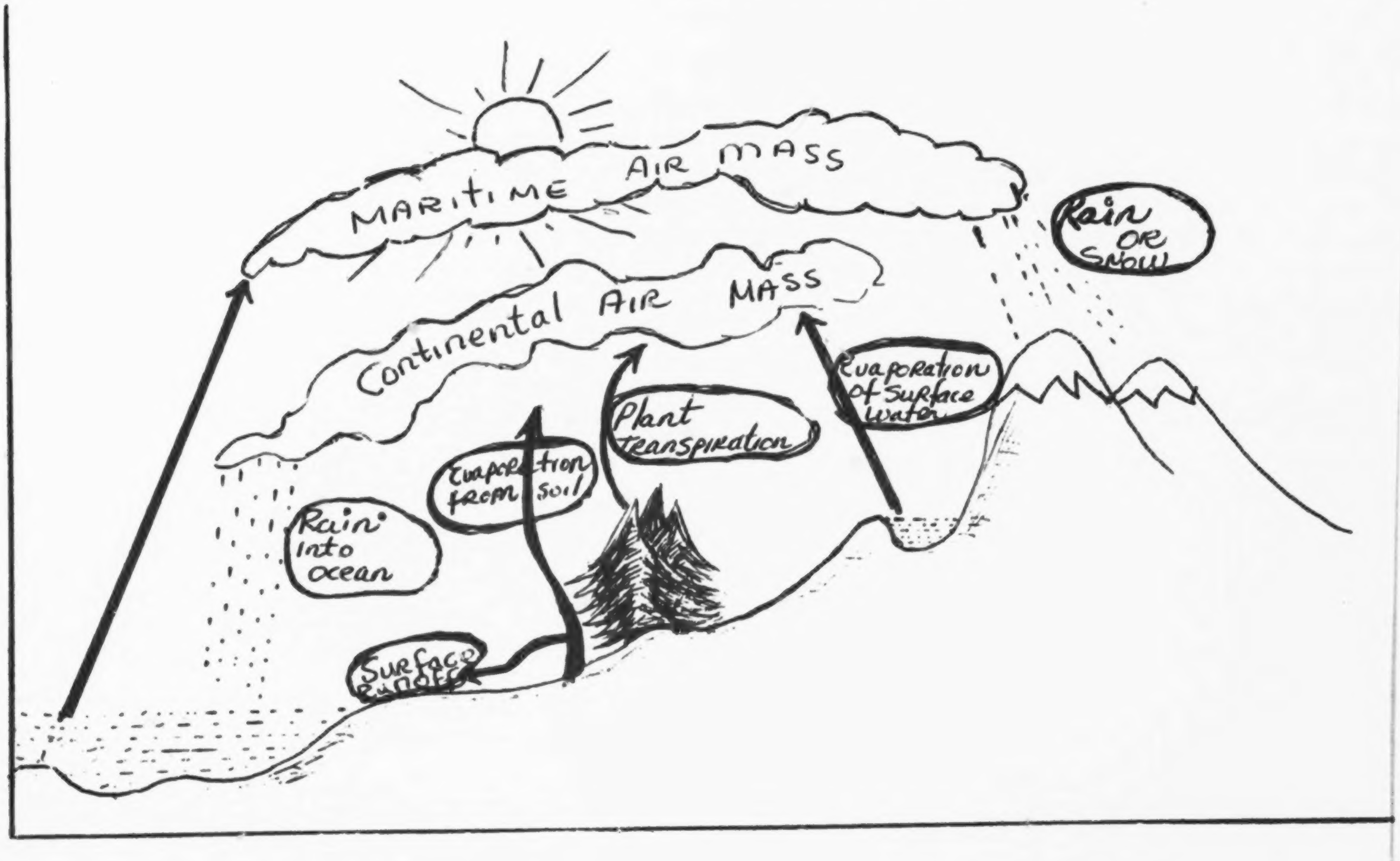
To understand and learn the pathways of the water cycle and its relation to the distribution of living things

ACTIVITY MATERIALS

Flannel board cutouts of water cycle or a bulletin board display
Ditto sheets showing the water cycle

WHAT TO DO

Prepare ditto sheets of water cycle. Students fill out and label important elements of the cycle. Students write a short paragraph explaining the importance of the cycle and the pathways of the cycle.


MARITIME AIR MASS
Rain or Snow
Continental AIR MASS
Evaporation of Surface water
Plant transpiration
Evaporation from soil
Rain into ocean
Surface Runoff

NITROGEN IN SOIL

PURPOSE

To understand that nitrogen is found in soil in the form of nitrates

ACTIVITY MATERIALS

Samples of soil: clay, fertile topsoil, sand, and others
Test tubes
Distilled water
Solution I (1 part glacial acetic acid to 3 parts of distilled water)
Solution II (0.03 g of diphenylamine dissolved in 25 ml of concentrated sulfuric acid)
Funnels
Filter paper
Beaker

WHAT TO DO

PART A

Place a small portion of soil sample in test tube and add 15 ml of distilled water. Add one drop of Solution I to the test tube. Shake vigorously for one minute. Pour the contents through funnel fitted with filter paper and run filtrate into a beaker. Place some of the filtrate into a watch glass and add 8 drops of Solution II. If a blue color develops in five minutes, nitrates are present. Repeat this procedure for each soil sample to be tested.

Fill the summary chart given below with information gathered from this exercise.

How do these results help us to understand the source of nitrogen in plant materials?

Adapted from Lawson, Chester, et al. Laboratory Studies in Biology. San Francisco: Freeman Co., 1958. p. 310-312. (A good reference)

PART B

If possible obtain soil samples as follows:
A. Unfertilized soil prior to growing corn(B.) B. Same as A but after corn crop had been grown on it (C). Same as B but after a crop of clover, soy bean, or other legume has grown on it. Test each of these samples as suggested above.

SUMMARY CHART FOR PART A

Soil Type	Negative	Positive
Clay		
Sand		
Fertile Topsoil		
Others		

SUMMARY CHART FOR PART B

Soil Type	Negative	Positive
Unfertilized Soil		
After Corn		
Unfertilized		
After Clover or Other Legume		
Others		

UNIT THREE: DISTRIBUTION OF LIFE

FOREST FIRES
Effects on Natural Communities

PURPOSE

To learn and understand the need for fire prevention and control in forested areas of our community.

ACTIVITY MATERIAL

Ditto sheet of pictures or Scientific American reprints by Charles Cooper, "The Ecology of Fire," April, 1961.

WHAT TO DO

"Study Figure 1 and 2. Which population is increasing in size? (1) Decreasing? (2)

The roots of mesquite have been found penetrating mine shafts many feet below the surface of the soil. What competitive advantage of mesquite over grasses does this suggest? (3)

If the trend shown in Figures 1 and 2 continues, what kind of community would eventually occupy this area? (4)

Now refer to Figures 3 and 4. In Figure 3 the light areas of the plants at or below ground level represent the unharmed growing tissues of the two kinds of plants. Can both kinds of plants survive the fire? (5)

Which kind of plant has lost more of its growing tissue? (6)

Grasses usually reach maturity and produce seeds in one or two years. Mesquite usually requires four or more times this period. In the area shown one year after the fire, which kind of plant is shown as occupying most of the land? (7)

Refer to the answer given in number six and the information provided in the paragraph above and explain the competitive advantages of grass over mesquite after the area is burned over. (8)

What might you expect the area shown in Figure 4 to look like four or five years after the fire? (9)

Taken from High School Biology, Green Version - The Laboratory, Part One, Exercise 6.6, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

If the area is burned regularly about every four years for a period of 200 years what kind of plant or plants might you expect at the end of the 200-year period? (10)

In parts of the country the invasion of shrubs into grassland areas continues today. One writer estimates that about 70 million acres of grassland is now occupied largely by mesquite. Some ecologists blame the invasion largely upon the use of this land by cattle. They argue that cattle have reduced the grasses and that the less tasty mesquite is thus allowed to increase. Suggest a way of testing this hypothesis? (11)

At the time the Europeans colonized the north central states the forests of this area were made up of three types of trees. See Figure 5. Some of these forest areas are now occupied almost entirely by a single species. Study Figures 5-9, which show how this change was brought about. Which plant has a competitive advantage after the area is burned over? (12)

Assume that the area shown in Figure 9 is burned over. What type of forest might you expect to find here 20 years after the burning? (13) Explain. (14)

What type of forest might you expect to find here 200 years later if the area is burned more or less regularly at 20-year intervals? (15)

One of the economically important trees of this region is the longleaf pine. Its pattern of growth is different from most pines in that it will remain in the "grass" stage shown in Figure 10 from three to seven years. During this time the pine develops a deep root system and stores a considerable amount of food. The long green needles of the "grass" stage protect the growing tissues of the pine from surface fires.

At the end of the "grass" stage the pine grows very rapidly--as much as four or more feet a year for several years. This period of rapid vertical growth is shown in Figures 12 and 13. Light ground fires do not injure the trunks of the larger trees shown in Figures 13 because the thickened bark provides insulation. Neither is the vulnerable bud injured because it is now six or more feet above the ground.

Study Figures 10 and 11 and recall the effect of fire on the mesquite of the grasslands. What would you expect to be the fate of the deciduous saplings shown in the middle ground of these fires? (16) Which kind of plant has a competitive advantage after the area is burned over? (17)

Now assume that this area is burned every four or five years. What do you think the area shown in Figure 14 would be like at the end of a 200-year period? (18)

In this exercise you have learned some of the effects of fire in three different communities. Explain briefly how periodic fires may change each of the three original communities. (19)

EFFECT OF TERRACING

PURPOSE

A visual method to demonstrate the effect of terracing in soil conservation

ACTIVITY MATERIALS

Strips of paper toweling
Masking tape

WHAT TO DO

Paste strips of paper toweling across a small section of the slate blackboard. Dash some water on the board and as the small rivulets of water flow down along the board the paper toweling will help slow down the flow or even stop the flow of the water. See Figure 1.

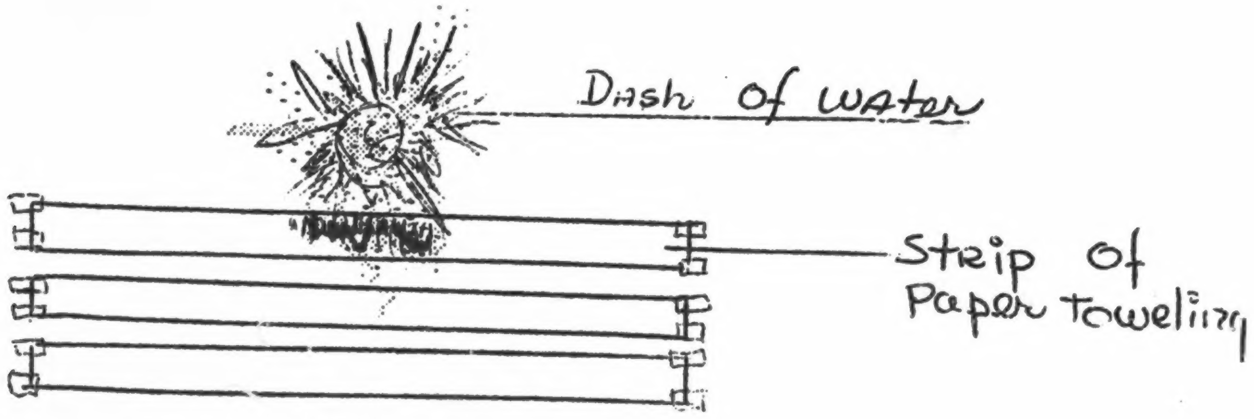


Figure 1

Reference: Morholt, Brandwein, and Joseph. A Sourcebook for the Biological Sciences. New York: Harcourt, and Brace, 1958. p. 239.

EROSION AND THE SLOPE OF THE LAND

PURPOSE

To understand the mechanics of good soil conservation practices and the need for such practices.

ACTIVITY MATERIALS

Three boxes (one foot deep and three feet square)
Loam soil
Cover crop, such as rye, grass, oats, barley, and others

WHAT TO DO

Fill each of three boxes with loam soil. In one box of loam plant a crop of fast growing cover, such as rye, barley, grass, or oats. When the cover crop is thick with growth start the demonstration. Tilt one box of loam at an angle to represent a slope of land; allow one box of loam to lie flat to represent flat land; tilt the box with the thick growth of cover vegetation to represent sloped land with vegetation. Have students direct a gentle spray on the three boxes. What are the differences in each? How much of the soil has been carried away in each box? What is the effect of the cover crop?

"Plowing." Students build two mounds of topsoil as shown in Figure 1.

Students plant "crop" in one mound in furrows which circle the mound. Plant the other mound in furrows that run vertically from the top of the mound. Pour equal quantities of water over each mound. How does the runoff water (with soil) compare in the two plowing techniques described?

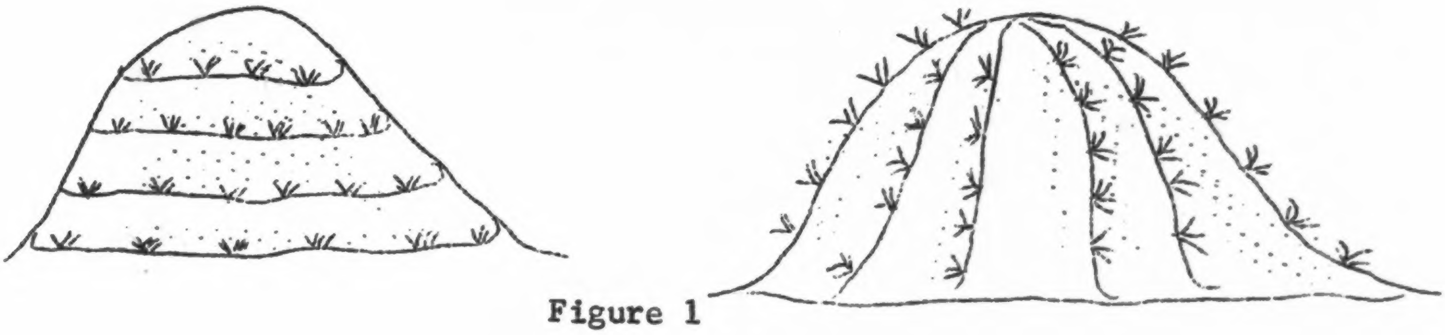


Figure 1

Reference: Morholt, Brandwein, and Joseph. A Sourcebook for the Biological Sciences. New York: Harcourt, and Brace, 1958. pp. 238-239.

SOIL PROFILE

PURPOSE

To understand the make up of soil through a profile study

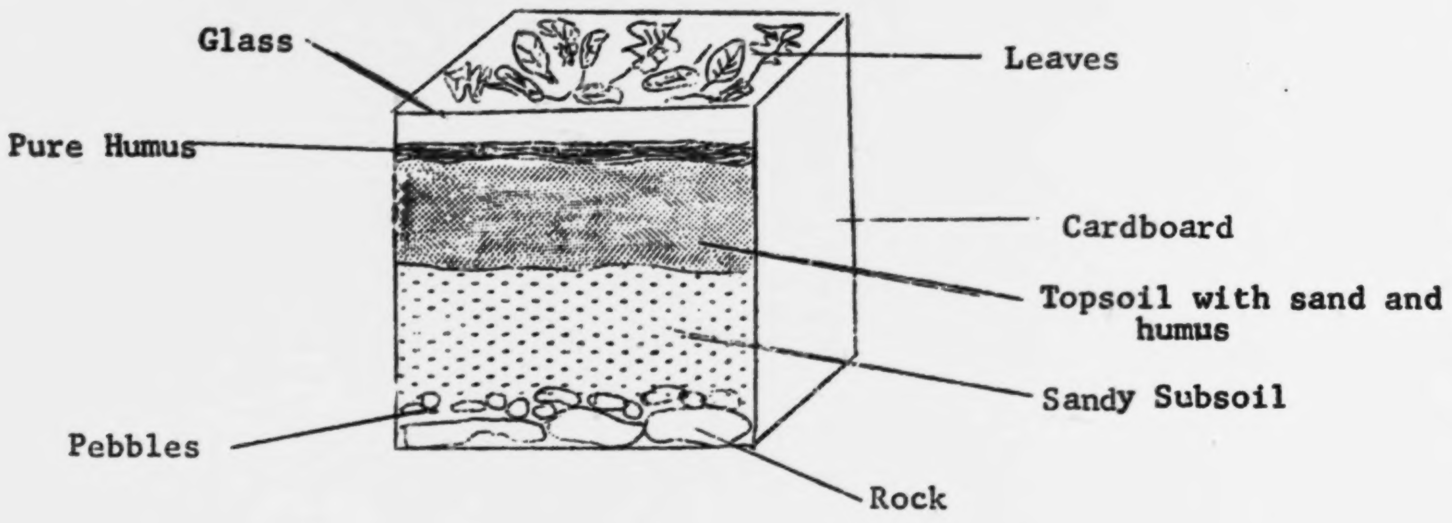
ACTIVITY MATERIALS

Two or three pieces of heavy cardboard
Two panes of glass
A box (wood or heavy cardboard)
Various materials, such as:

Large pieces of rock	Topsoil containing sand and humus
Small pebbles	A layer of pure humus
Sandy subsoil	A layer of freshly fallen leaves

WHAT TO DO

Prepare a soil profile by placing all soil samples as directed between two panes of glass and two pieces of heavy cardboard with a box or cardboard box as the "floor." First layer on the floor of the profile should be large pieces of rock; second layer should be smaller pebbles; third layer sandy subsoil; fourth layer--topsoil containing sand and humus; fifth layer--pure humus; sixth layer (top layer)—a layer of freshly fallen leaves.



Adapted from Ella Thea Smith, Exploring Biology, 5th Edition, Teacher's Manual (New York: Harcourt, Brace, and World, 1961), p. 249. Permission granted by publishers.

NATURE'S HOUSE THAT JACK BUILT

PURPOSE

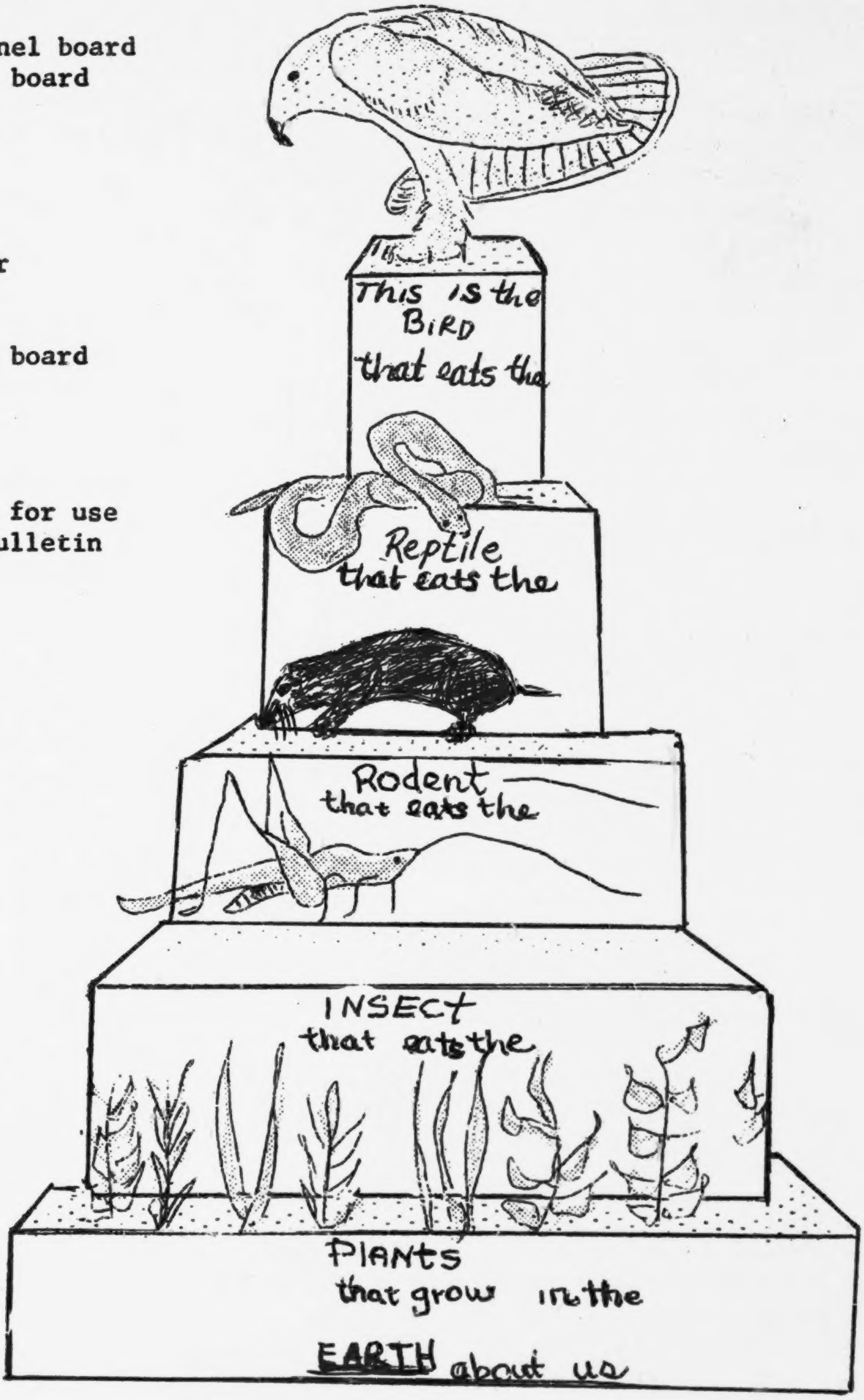
An illustration of a flannel board demonstration or bulletin board design.

ACTIVITY MATERIALS

Colored construction paper
Scissors
Flocking paper backing
Flannel board or bulletin board

WHAT TO DO

Enlarge design as shown for use on the flannel board or bulletin board.


This is the
Bird
that eats the
Reptile
that eats the
Rodent
that eats the
INSECT
that eats the
PlAnts
that grow in the
EARTH about us

UNIT THREE: DISTRIBUTION OF LIFE

CONCEPTS TO CONSIDER

Population is a group of organisms of the same or similar species which occupy a given area.

Characteristics of a population are the function of the whole group and not of single individuals; population density, birth rate, death rate, rate of migration, rate emigration, and age distribution.

The number of organisms plotted on a curve against a time unit forms a population growth curve. The shape of a growth curve is similar for all populations -- S-shaped.

The mortality rate of a population refers to the number of individuals dying per unit of time.

The natality rate (or birth rate) of a population is the number of new individuals produced per unit of time.

Once a population becomes established in a certain region and has reached the equilibrium level, the numbers of the population will vary up and down from year to year; some of these variations will be regular and cyclic.

Populations have a tendency to disperse in all directions until some barrier is reached.

Any given area tends to have an orderly sequence of communities, which changes together with the physical conditions, which leads finally to a stable mature community or climax community.

Succession of plants will occur whenever an area of land is denuded of vegetation and then, left to itself, it undergoes a regular series of events which result ultimately in return to a type of vegetation which is self-perpetuating and permanent.

TEACHING APPROACH (Methods and Activities)

Discuss the growth of populations

- Illustrate the growth of human populations by writing on the chalk board the following table:*

Year	Population of World	Scientific Notation
7000 B.C.	10,000,000	(10^7)
A.D. 1	200,000,000	(2.0×10^8)
A.D. 1650	500,000,000	(5.0×10^8)
A.D. 1950	2,500,000,000	(2.5×10^9)
A.D. 1960		

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*Ella Thea Smith, Exploring Biology, 5th Edition, Teacher's Manual (New York: Harcourt, Brace, and World, 1961), p. 246. Permission granted by publishers.

- Have students plot a graph to show the steep rise in recent years of world human population growth.
- Demonstrate a population growth study by experiment with yeast populations suggested on page 235-239.
- Students plot growth curves on graphs.
- Discuss density as a characteristic of a population.
- Give examples of how density of populations of organisms are used in making comparisons.
- Explain meaning of rates and their interactions as in rate of dispersal, mortality rate, natality rate, and others.
- Using the flannel board or chalk talk demonstrate rates as suggested on page 245.
- Discuss dispersal (emigration or immigration), natality, and mortality as effecting a population size.
- Correlate findings of yeast population study with information given above.

Discuss limiting and balancing factors

- Assign students to read excerpts of the University of Wisconsin experiments studied by John Emlen on the effect of food and space on population size. Students report and discuss experimental studies.
- Assign students to report about experimental studies on effect of food and space on population size, such as Paul G. Pearson at Rutgers University and experiments done in England.
- Students learn about predator-prey relationships and their effect on a population study. Demonstrate this principle by doing experiment suggested on page 242.
- Assign students homework on population study of Kaibab deer on pages 240-241.
- After homework has been collected, open discussion on Kaibab deer by reviewing questions and answers in homework assignment. Use terms such as predator-prey relationship, competition, density, and others. A good reference is Simpson, G., et al. Life: An Introduction to Biology. New York: Harcourt, and Brace, 1957. pp. 653-656.
- Assign some students to report on Malthus, Thomas. Essay on the Principle of Population as It Affects the Future Improvement of Mankind. See page 234.
- Discuss the Malthusian principle (and Darwin and Wallace).
- Discuss periodism, either cyclic or irregular.

- Make a list of periodicities that occur in daily cycles, such as nocturnal predators in the desert; bees and wasps are diurnal insects, flycatchers and bats are dawn or dusk animals, and so on.
- Prepare a bulletin board showing the vertical migration of plankton, which exhibits daily periodism. See page 245 for suggested diagram for bulletin board display.
- Discuss cycles of animal activity that follow the phases of the moon and affect tides, which directly affect certain animals, such as the grunion, palolo worms, and others.
- Discuss other cyclic rhythms that occur in land animals.

Discuss succession of plant and animal populations.

- Demonstrate ecological succession in the laboratory by doing experiment suggested on pages 246-247.
- Discuss succession in a protozoan culture after laboratory experience.
- Students do homework assignment on temporary pond succession as suggested on pages 248-251.
- Discuss a sand dune succession.
- Students do homework assignment on sand dune succession. See pages 252-254.

DEPTH PROBE

- POPULATION STUDY, pp. 235-239 (Average Student Basic Activity)--To understand that populations of living organisms tend to reproduce at a certain rate and that limiting and balancing factors will modify and change the population growth. Students work in groups.

- LIMITING AND BALANCING FACTORS IN A POPULATION, pp. 240-241 (Average Student Basic Activity)--To learn and understand some of the factors that tend to limit and balance a population size. Students work individually as homework.

- PREDATOR-PREY RELATIONSHIPS, p. 242 (More Able Student Basic Activity)--To learn about predator population's effect on the size of a prey population. Students work in groups.

- RATES, pp. 243-244 (Average Student Basic Activity)--To learn and understand the use of rates in interpreting some aspects of a population. Student/teacher demonstration.

- DAILY PERIODISM IN MARINE PLANKTON, p. 245 (Average Student Basic Activity)--To illustrate the vertical migration of marine plankters, which aids in demonstrating a type of daily periodism. Teacher demonstration.

- ECOLOGICAL SUCCESSION IN A MICROENVIRONMENT, pp. 246-247 (Average Student Basic Activity--Optional)--To understand the concept of ecological succession as demonstrated by small aquatic environments set up in the laboratory. Students work in groups.

- TEMPORARY POND SUCCESSION, pp. 248-251 (Average Student Basic Activity)--To learn some basic understandings about succession of living organisms in a temporary pond. Students work individually.

- SAND DUNE SUCCESSION, pp. 252-254 (Average Student Basic Activity--Optional)--To learn some basic understandings about succession of living organisms in a sand dune. Students work individually.

- PLANT SUCCESSION, p. 255 (Average Student Basic Activity--Optional)--A design for a bulletin board display. Teacher and student demonstration.

"TOOLS" FOR EXTENDING CONCEPTS

- Encourage some students to prepare a report on succession in human communities.

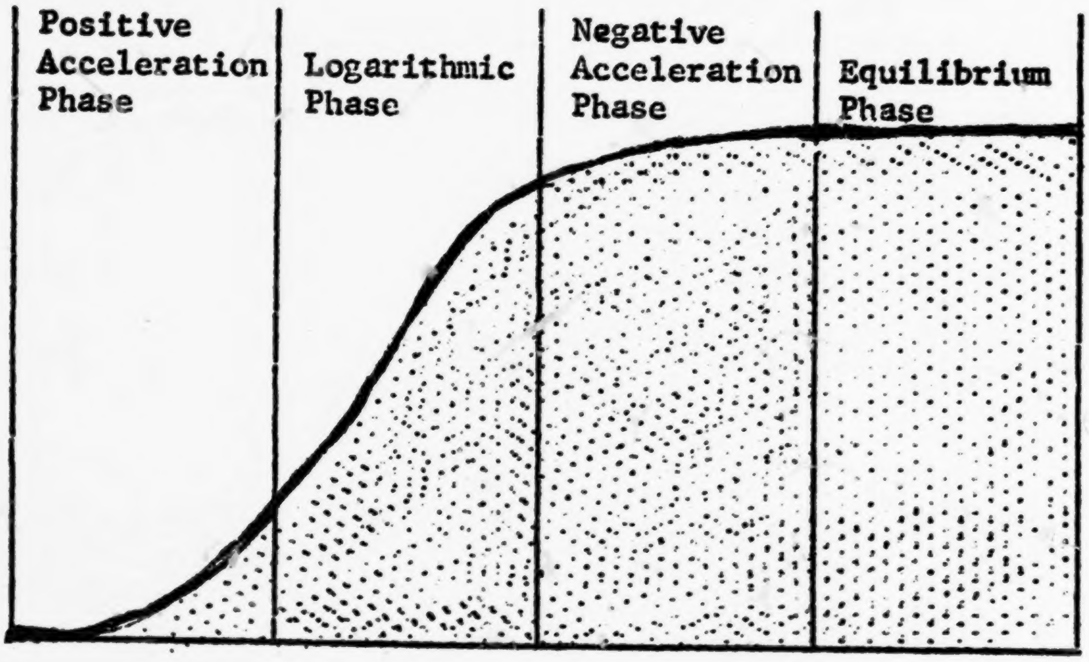
- Plan to show films

  "World in a Marsh," Fsd 591.5-30
  "The Spruce Bog; An Essay in Ecology," Fsd 634.97-1
  "The Changing Forest," Fsd 634.9-48
  "Fish Out of Water," Fsd 597.5-1
  "Succession from Sand Dune to Forest," Fsd 574.5-5

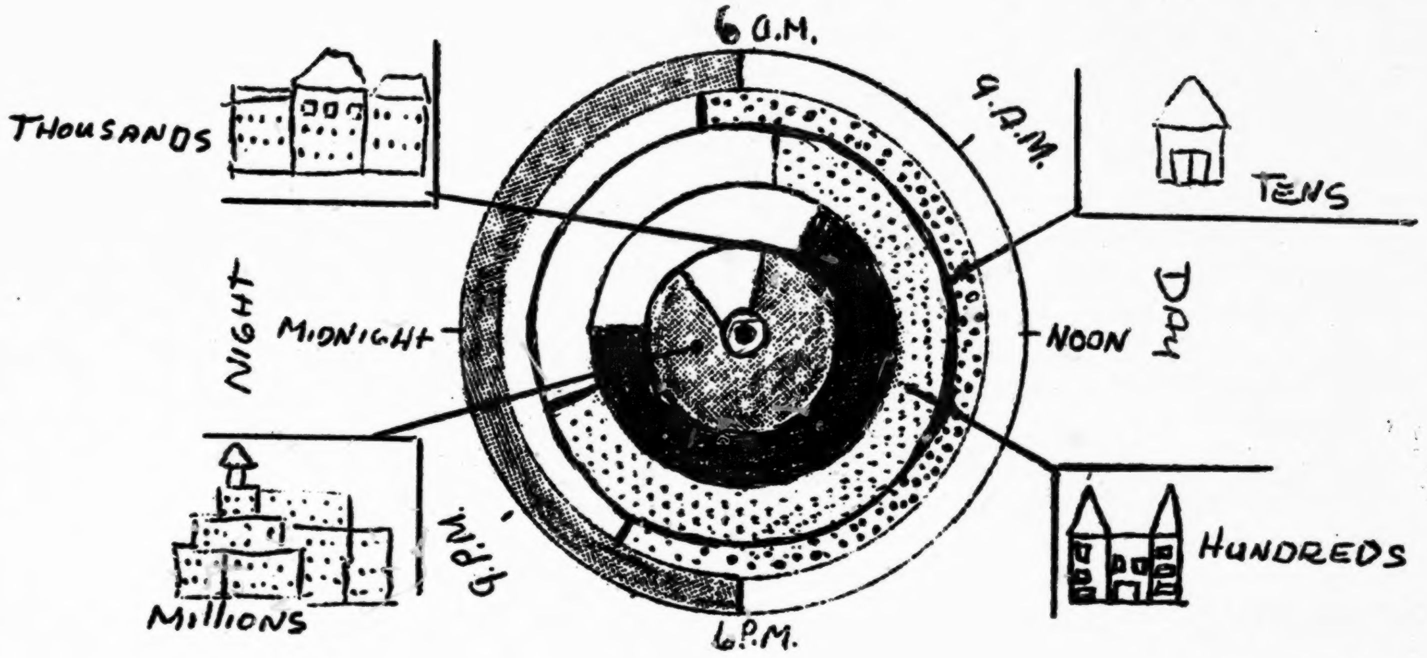
- Encourage students to read experimental studies done in the field by David E. Davis. "The Characteristics of Rat Populations," Quarterly Review of Biology, (1953) 28:373-401.

- Assign some students to report on regular and irregular periodicities of animals, such as lemmings, locust, grunion, and others.

- Encourage several students to make an ecological survey of a seashore estuary succession and present material to class in report and poster form.
- Assign some student to report on a variety of predator-prey relationships and correlate these to population growth, such as hare-lynx; snowy owls and foxes -- lemmings and voles; and others.
- Assign a student team to do research on microsuccession in a rotten log. An oral report of research, bulletin board display and notebook work should be presented to the class.
- Assign a student to read and report on book, Malthus, Thomas, J. Huxley, and F. Osborn. On Populations: Three Essays. New York: Mentor Books, 1960.
- Encourage students to keep an ongoing list of those living organisms that exhibit a diurnal periodism, and those that exhibit a nocturnal periodism.
- Encourage a student to report on the devasted island of Krakatau in the Malay Archipelago (1883). What type of animal and plant succession has taken place since then?
- Assign students the task of learning about succession after forest fires in the Santa Monica Mountains of Southern California.
- Assign some student groups to research population studies of California Quail by John Emlen, "Sex and Age Ratios in Survival of the California Quail," (1940). Journal of Wildlife Management 4:92-99.
- Prepare a bulletin board showing a sigmoid curve of population growth.



- Prepare a bulletin board display to show levels of periodicity or aperiodicity of man.*


6 A.M.
9 A.M.
THOUSANDS
TENS
DAY
NIGHT
MIDNIGHT
NOON
MILLIONS
9 P.M.
6 P.M.
HUNDREDS

- Prepare a bulletin board showing sand dune succession as suggested on page 252.
- Encourage some students to build a three-dimensional model of a temporary pond succession as suggested on pages 248-251.
- Encourage some student groups to report on convergence in ecological succession as shown.** (page 232)

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*Drawn after W. C. Allee, et al., Principles of Animal Ecology (Philadelphia, Pa.: Saunders, 1949), p. 560. By permission of publishers.

**Ibid., p. 576.

Sand Ridge	Clay Bluff
Cottonwood	Aspen
Gray Pine	Cottonwood
Black Oak	Hop-hornbean
White Oak	White Oak
Red Oak	Red Oak
Hickory	Hickory

BEECH AND SUGAR MAPLE

Tulip	Hickory
Basswood	Red Oak
White Elm & White Ash	Bur Oak
Swamp White Oak	Basswood
Buttonbush	Hawthorn
Cattail & Bulrush	Slippery Elm & White Elm
Water-lily & Water mill-foil	River Maple
Chara	Black Willow
Pond	Flood Plain

PLANNING AHEAD

- Locate and reserve several 1-ml pipettes for potometer experiment.
- Locate and store several two-hole rubber stoppers, battery jars, rubber tubing, ringstands, burrette clamps, flasks, and glass tubing.
- Reserve a class set of atlases from the textbook clerk for use in next section.
- Locate a globe of the world or borrow the planetarium from science department.
- Collect temperature and rainfall records of various places all over the world.
- Prepare a bulletin board entitled OUR PHYSICAL ENVIRONMENT.
- Assign a student group to prepare a poster on the various layers of atmosphere that encircle our earth.
- Assign some students to locate information on the temperature ranges of a variety of plants and animals.
- Assign a student group to investigate the general wind patterns of the earth and also the general ocean currents.
- Encourage some students to read about tides and currents and their effects on the distribution of living things.
- Assign a student to locate information on the distribution of chemicals in the ocean.
- Locate information on the effects of salinity on living organisms.
- Encourage some students to learn how to test soil acidity.
- Prepare a bulletin board showing the EFFECTS OF LATITUDE AND ALTITUDE on the distribution of living organisms.

BROADENING "CONTENT HORIZONS"

Teacher References:

Allee, W. C., et al. Principles of Animal Ecology. Philadelphia, Pa.: Saunders, 1961.

Franklin, Thomas. Climates in Miniature. London: Faber, 1955.

Odum, E. P. Fundamentals of Ecology, 2nd Edition. Philadelphia, Pa.: Saunders, 1959.

Elton, Charles. Animal Ecology. New York: Macmillan, 1927.

Boell, E. J. Dynamics of Growth Processes. Princeton, New Jersey: Princeton University Press, 1954. Chapter XIII, "Quantitative Aspects of Population Growth"

Simpson, G., et al. Life: An Introduction to Biology. New York: Harcourt, and Brace, 1957. (Title III - Collection)

Benton, Allen, and W. E. Werner. Principles of Field Biology. New York: McGraw-Hill, 1958. (Title III - Collection)

Woodbury, A. M. General Ecology. Philadelphia, Pa.: Blakiston, 1954.

Oosting, H. J. Plant Communities. San Francisco: Freeman, 1956.

Clarke, G. L. Elements of Ecology. New York: John Wiley and Sons, 1954.

Elton, C. Voles, Mice, and Lemmings. Oxford: Clarendon Press, 1942.

Elton, C. Ecology of Invasions by Animals and Plants. London: Metheun, 1958.

Lack, D. Natural Regulation of Animal Numbers. London: Oxford, 1954.

Brown, Frank. "Studies of the Timing Mechanisms of Daily, Tidal, and Lunar Periodicities in Organisms," Perspectives in Marine Biology. Berkeley: University of California, 1958.

Deevey, Edward. "The Human Population," Scientific American, (Sept., 1960)

UNIT THREE: DISTRIBUTION OF LIFE

Student References:

Simpson, G., et al. Life: An Introduction to Biology. New York: Harcourt, and Brace, 1957. (Title III - Collection)

Dowdeswell, W. H. Animal Ecology. New York: Harper Torchbooks, 1961.

Storer, John. Web of Life. New York: Mentor Books, 1961.

Buchsbaum, Ralph and Mildred. Basic Ecology. Pittsburgh, Pa.: Boxwood Press, 1961.

Malthus, T., J. Huxley, and F. Osborn. On Population: Three Essays. New York: Mentor Books, 1960.

Dice, L. R. Man's Nature and Nature's Man: The Ecology of Human Communities. Ann Arbor: University of Michigan Press, 1955.

Textbook References:

Moon, Otto, and Towle. Modern Biology. pp. 56-77.

Smith, Ella Thea. Exploring Biology, 5th Edition. pp. 602-620.

POPULATIONS AND COMMUNITIES
RISE AND FALL OF POPULATIONS
LIMITING AND BALANCING FACTORS

UNIT THREE: DISTRIBUTION OF LIFE

POPULATION STUDY

PURPOSE

To understand that populations of living organisms tend to reproduce at a certain rate and that certain limiting and balancing factors will modify and change the population growth.

ACTIVITY MATERIALS

Fleischmann's dry active yeast
Test tubes
Aluminum foil squares
Microscope slides and coverslips
Medicine droppers or 1 ml pipette
Graph paper
Erlenmeyer flask
Graduated cylinder
Balance scale
Yeast extract
Potassium phosphate, monobasic
Glucose
Peptone
Distilled water

WHAT TO DO

Prepare yeast growth medium. Mix 2.5 grams of yeast extract, 2 grams of potassium phosphate, monobasic, 40 grams of glucose, 5 grams of peptone, and 1,000 milliliters of distilled water. Dissolve in water by heating over a low flame. Place 15 ml of media in each test tube. Cover with a 3" x 3" square of aluminum foil or use a cotton plug. Place all test tubes in pressure cooker for 15 minutes at twenty pounds pressure. Store all sterilized test tubes with media in the refrigerator until ready to use. The media should appear a sparkling clear, slightly yellow color.

Students should be divided into "teams." Each "team" will have ten test tubes marked with a wax pencil or masking tape numbers from one to ten. Each team is given ten or more grains of (almost equal size) Fleischmann's dry active yeast. The test tube marked #10 is inoculated with one grain on Monday; the second test tube marked #9 is inoculated with one grain on Tuesday; third test tube marked #8 is inoculated with one grain on Wednesday; the fourth test tube marked #7 is inoculated with one grain on Thursday; the fifth test tube marked #6 is inoculated with one grain on Friday; the fourth test tube marked #5 and the third test tube marked #4 are inoculated each with one grain on Saturday and Sunday; (students assigned to take these two test tubes home should be impressed with which of the two tubes should be inoculated on Saturday and which on Sunday.) Test tube #3 is inoculated with one grain on Monday; test tube marked #2 is inoculated with one grain on Tuesday; test tube marked #1 is inoculated on Wednesday. Cell counts are to be made on the very next day, Thursday.

On the day of cell counts one member of each team inoculates one grain of yeast in 15 ml of water to determine the number of cells at "zero" hours of growth.

All ten test tubes should be incubated at room temperature between 22° C and 25° C. As each grain is placed in a test tube the tube should be mixed thoroughly and then placed in a can at room temperature.

On counting day you will want to know how many yeast cells there are in each test tube. Shake the test tube to be counted until it appears to be evenly suspended. Place two drops (0.1 ml) on a clean slide and cover. Focus under low power and then under high power. Count the number of yeast cells in five microscopic locations of your slide. See figure 1.

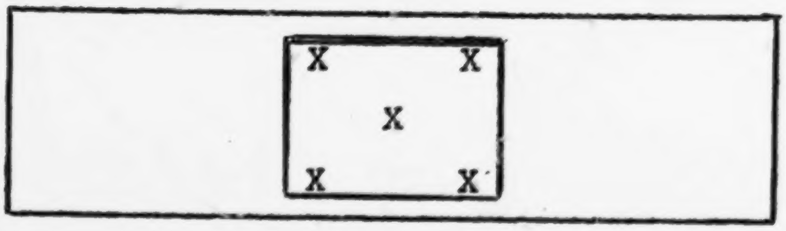


figure 1

After five areas have been counted, compute the average of the five fields. Have your partner count the same slide and compute the average of his five fields. Add your average to your partner's average and compute an average for this particular test tube cell count. If there are too many cells for easy counting, make the following dilutions. Pipette 9 ml of water into each of three empty test tubes. Number the tubes from one to three. Shake the yeast culture of a particular test tube until all of the cells are evenly distributed. Pipette 1 ml (20 drops) of culture into dilution tube number 1. Rinse the pipette carefully by drawing water from tube 1 in and out of the pipette. Mix tube number 1 thoroughly. Transfer 1 ml (20 drops) of solution from dilution tube number 1 to dilution tube number 2 following the same procedure as before. Mix tube number 2 thoroughly. Transfer 1 ml (20 drops) from dilution tube number 2 to dilution tube number 3 following the same procedure as before. Mix tube number 3 thoroughly.

Dilution tube number 1 culture material will be diluted 10 times; in dilution tube number 2, culture material will be diluted 100 times; in dilution tube number 3, culture material will be diluted 1000 times. See figure 2, page 237.

If you have counted an average of 15 cells per field in a sample from dilution tube number 2, the calculated number of cells per field in the original culture would be

15	X	100	=	1,5000
Average cell count		Dilution factor		Average cell count field of undiluted culture

Dilutions should be made of those culture tubes that are difficult for easy counting. Dilutions for new culture tubes should be made with clean test tubes and clean pipettes. Follow directions for dilution tubes as given in figure 3.

Record all information in chart.

Days of Growth	Team	Team	Team
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

figure 2

Average all counts for each day's growth from all classes doing this experiment and plot a graph to show the growth curve.

Compare the results of each team with each of the other teams. State similarities and differences of the curves. Give reasonable explanations for the similarities and differences.

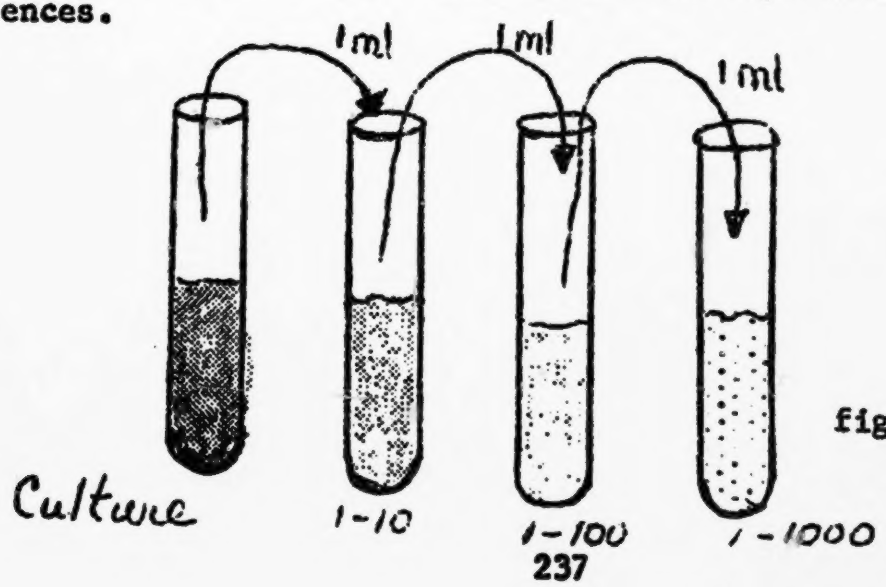


figure 3

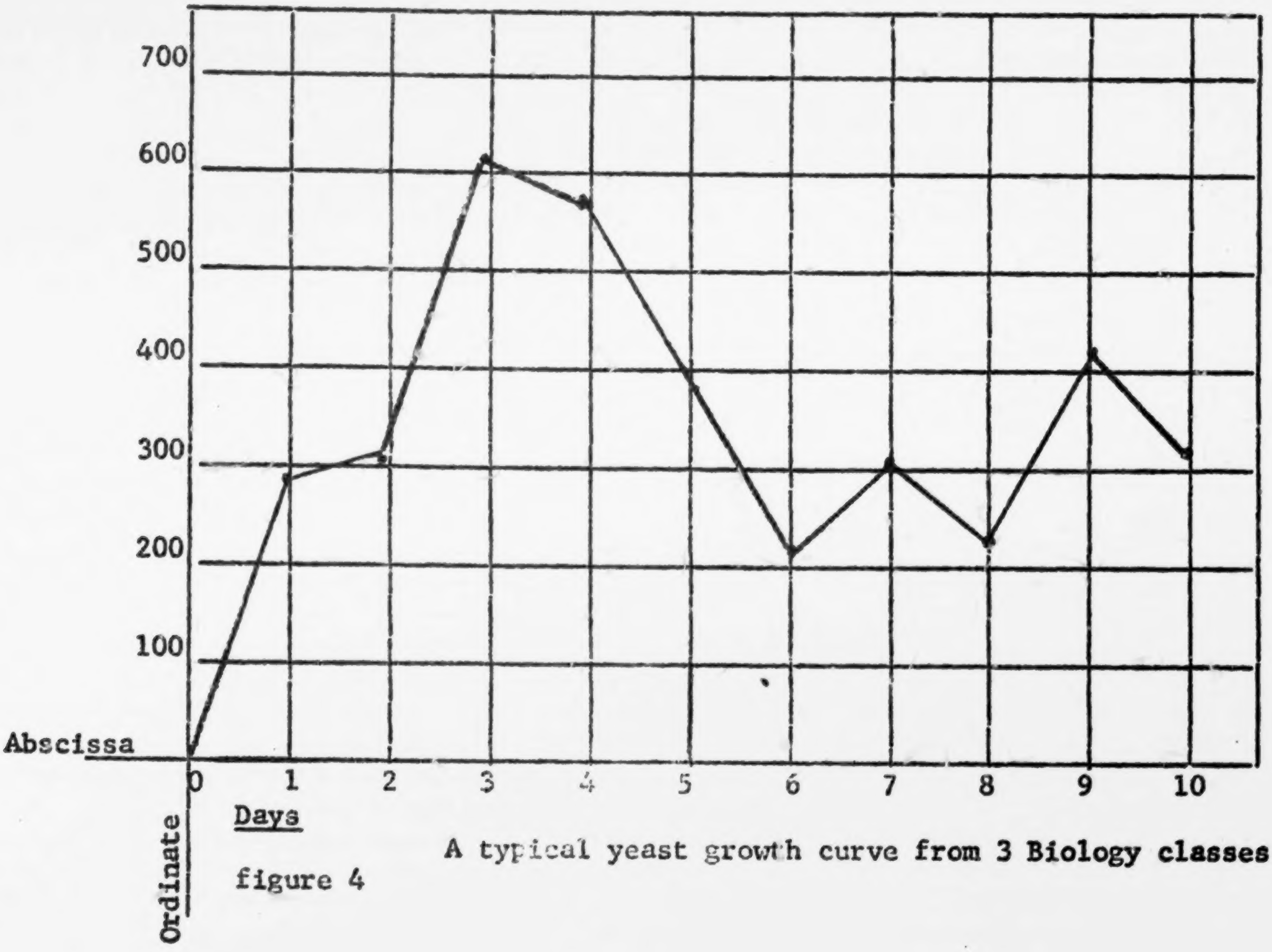


figure 4

A typical yeast growth curve from 3 Biology classes.

Plot an arithmetic graph of the following information:

figure 5

Years	Population
0	50
1	75
2	100
3	125
4	200
5	275
6	400
7	500
8	470
9	510
10	475
11	500
12	490

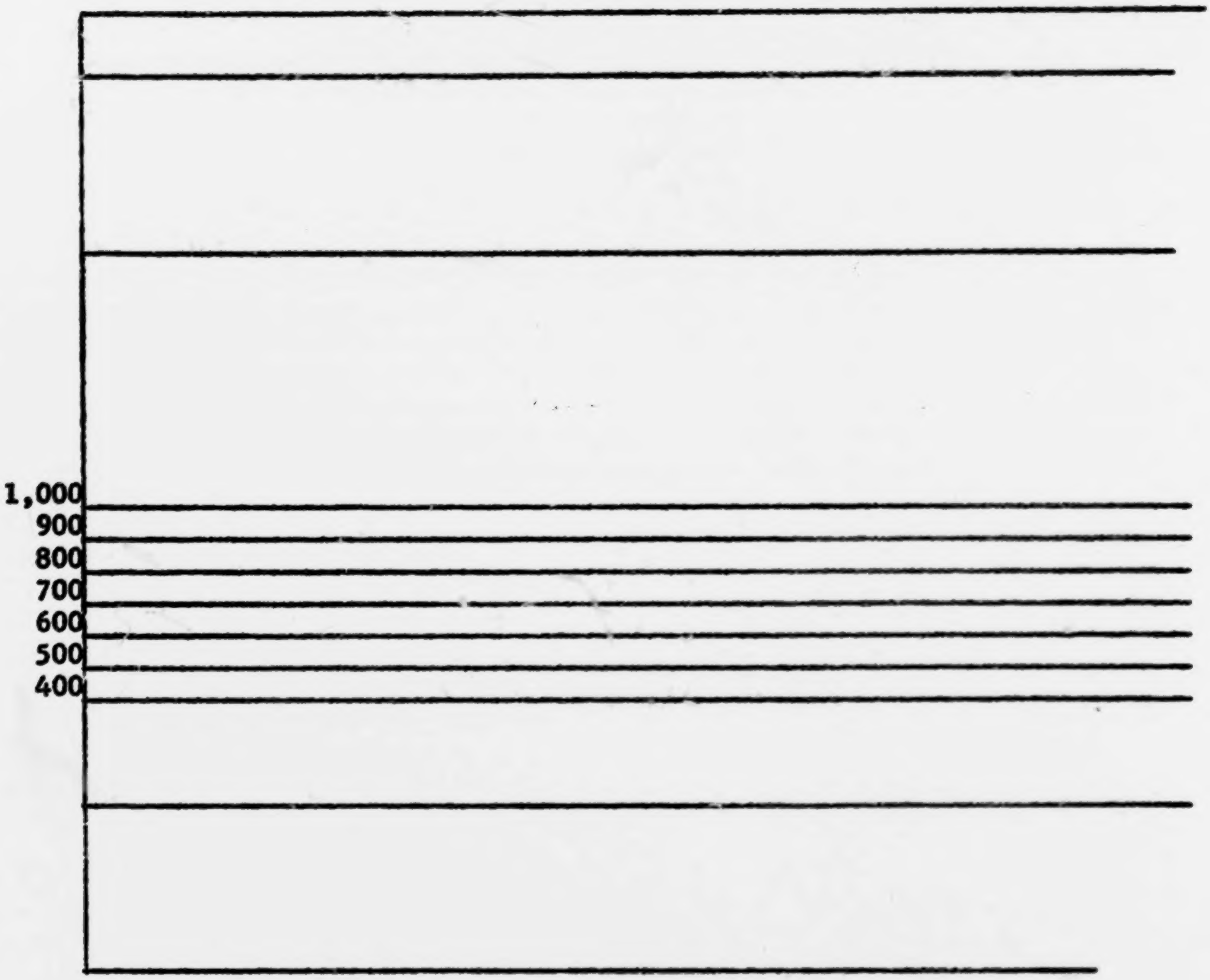
A Deer Population (figure 5)

What may happen to a population in nature after it attains its maximum size?

Why is this population behaving differently from a theoretical population as shown on figure 6?

Plot the theoretical population growth rate for five generations on graph in figure 6.

Assume that there are 5 breeding females in a beaver population and each breeding female has a reproductive capacity of 10 offspring per year. Let's assume that all offspring survive and reproduce themselves. Assume that one male and one female animal produce 10 offspring, half of which are female. Each of the 5 females gives birth to 10 offspring and again half are female, and so on. Assume that the parents die as soon as the offspring are produced.



Semi-Log figure 6

UNIT THREE: DISTRIBUTION OF LIFE

LIMITING AND BALANCING FACTORS IN A POPULATION

PURPOSE

To learn and understand some of the factors that tend to limit and balance a population.

ACTIVITY MATERIALS

Ditto sheet of growth curve shown in figure 1
Reference material other than textbook

WHAT TO DO

Answer the following questions from the chart given below in figure 1.

What was the population of the Kaibab deer in 1907? What is the normal capacity of the range on which the deer grazed? How was this population kept at a stable density in years between 1905-1910. What was the population of Kaibab deer in 1924? What caused the population to reach this peak? What was the relationship of deer population to the range capacity in (1924)? What happened (what percentage?) to the deer population in 1925-1926? Why did this happen? What is the population of the deer in 1939? Is this above or below the range capacity? If it is below, why is there a decline in the deer population?

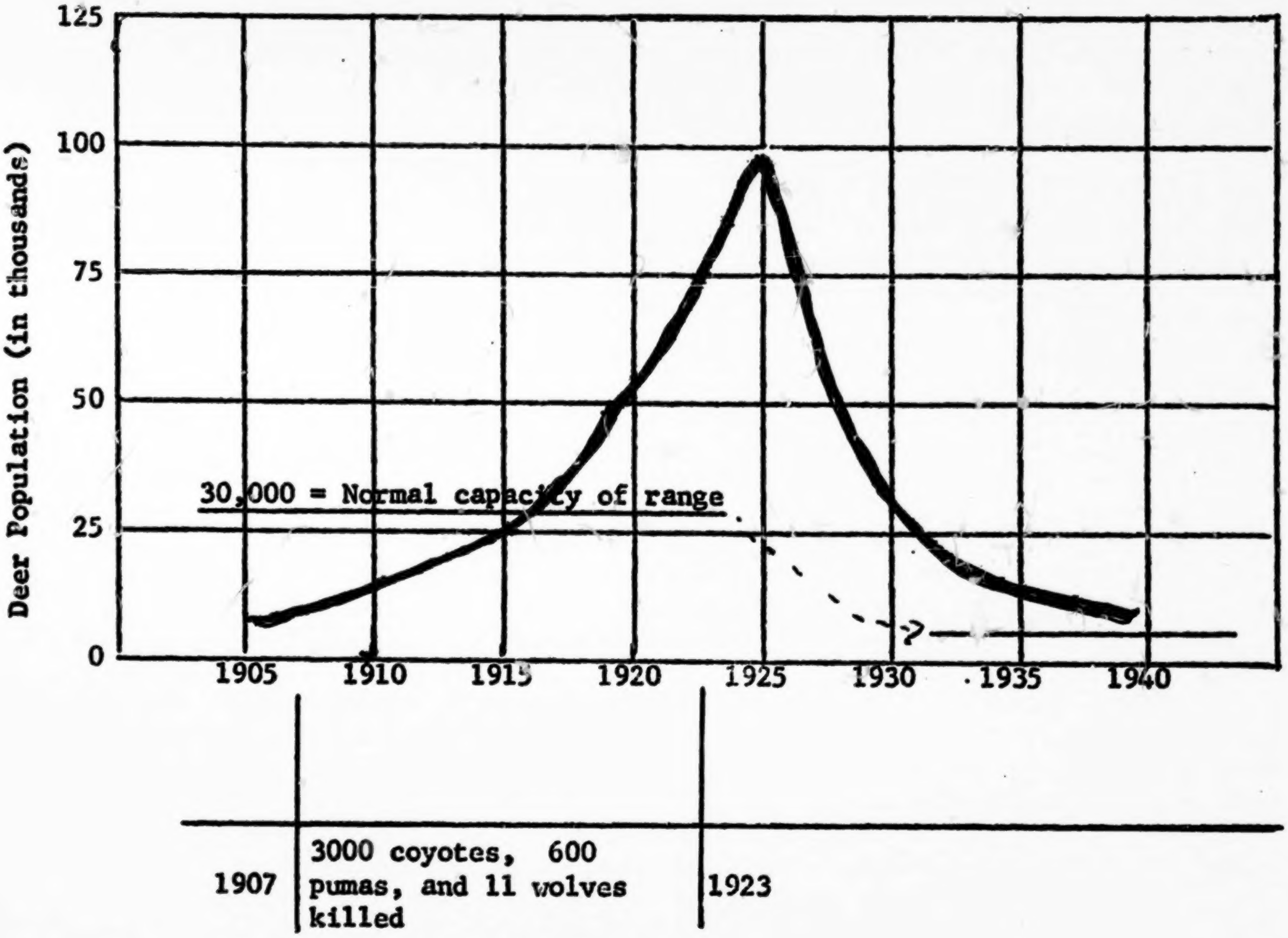


figure 1

G. Simpson, et al., *Life: An Introduction to Biology* (New York: Harcourt, Brace, and World, 1957), p. 655. Permission granted by publishers.

PREDATOR-PREY RELATIONSHIPS

PURPOSE

To learn about a predator population's effect on the size of prey population.

ACTIVITY MATERIALS

Pure culture of Paramecium caudatum
Pure culture of Didinium nasutum
Test tubes
Slides and cover slips
Microscope

WHAT TO DO

Prepare a test tube with a pure culture of Paramecium caudatum in 15 cc of medium. Make a count of animal number for three days in a row. Record data carefully. Add one drop of a pure culture of Didinium to the Paramecium culture on the third day. Make counts each day thereafter for a period of five days. Plot a curve showing the number of Paramecia each day (one through eight) using a dotted line and the number of Didinium each day (one through eight) using a black line. (figure 1)*

What happens when the Didinium becomes established? What happens to the Paramecium population? Why? What happens to the Didinium on the eighth day? Why? Which of the protists is considered to be the predator? Which of the protists is considered to be the prey?

Prepare a similar experiment using Paramecium aurelia and yeast cells.

Typical population curve of predator-prey relationships

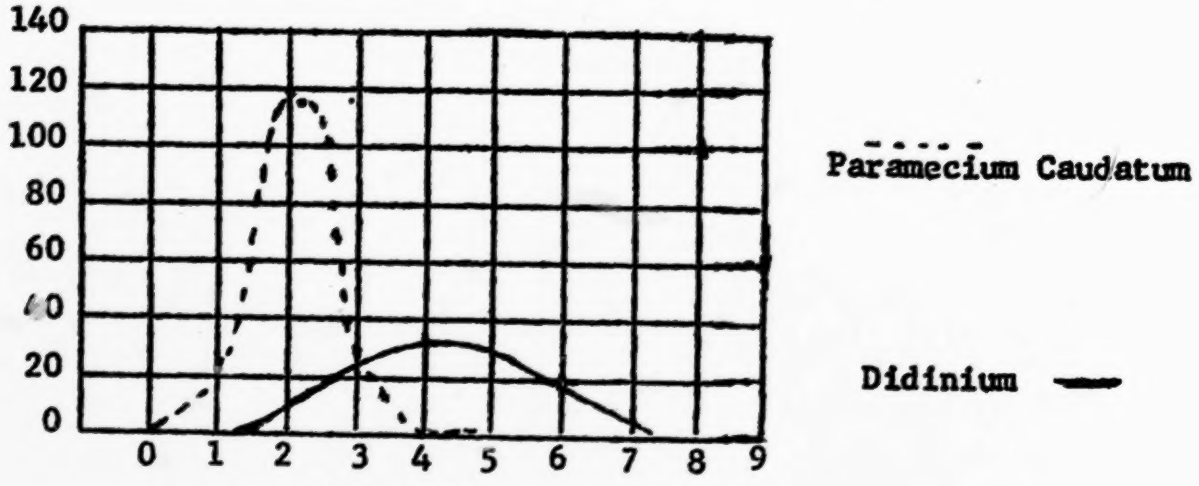


figure 1*

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*G. Simpson, et al., Life: An Introduction to Biology (New York: Harcourt, Brace, and World, 1957), p. 654. Permission granted by publishers.

RATES

PURPOSE

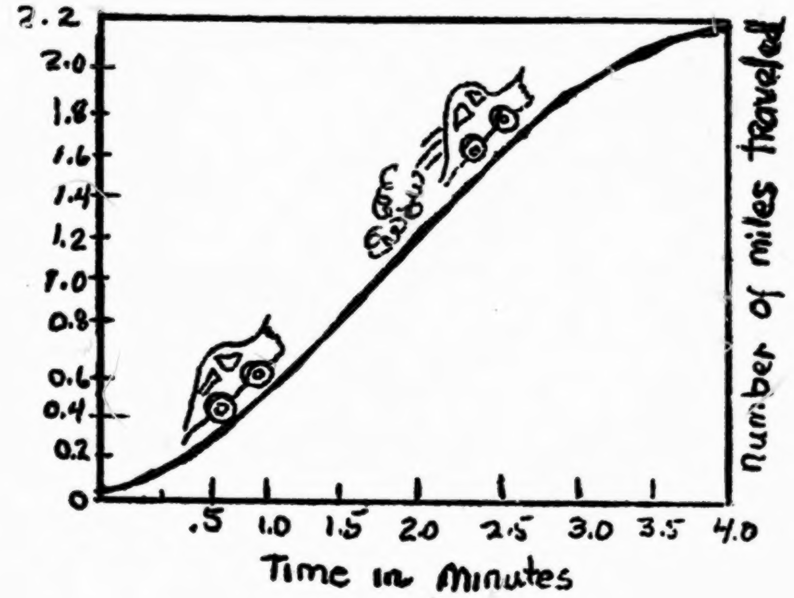
To learn and understand the use of rates in interpreting some aspects of population studies.

ACTIVITY MATERIALS

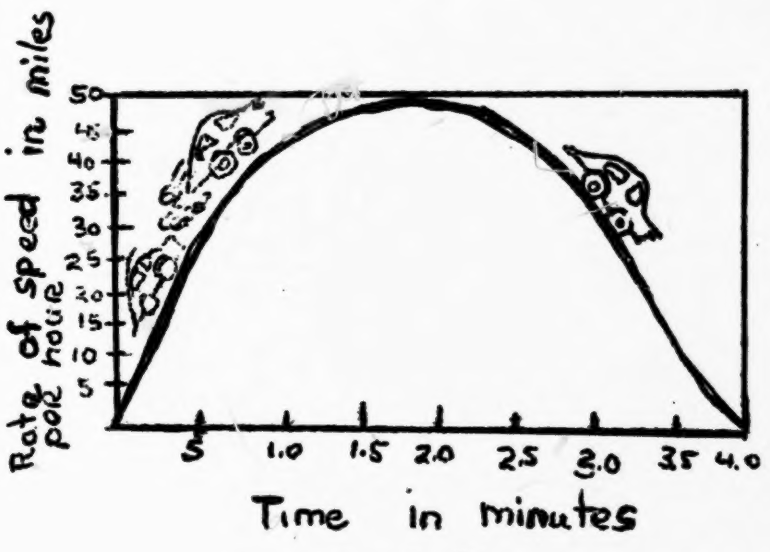
Drawings of graphs on the chalk board or flannel board
Small cutouts of automobiles or other vehicles
Reference material for students

WHAT TO DO

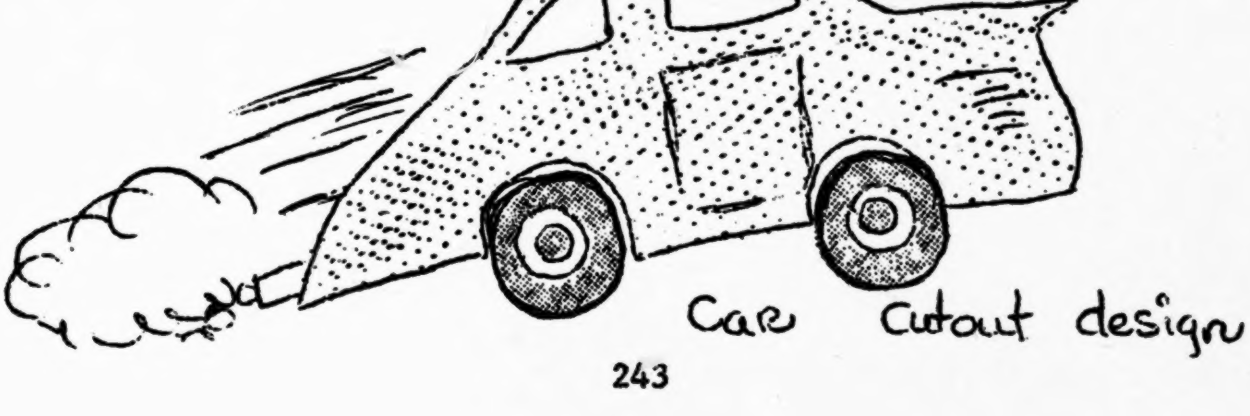
Prepare a graph on the flannel board or chalk board. Using the two graphs shown below and cutouts of an automobile, give an explanation of the use and interpretation of rates.



Graph #1



Graph #2



Graph #1

A careful record was kept of the number of miles traveled in an auto in four minutes. The distance traveled was 2.2 miles. The distance of 2.2 miles was then divided by four minutes and the rate of travel was 0.55 miles per minute. Although the traveling time for the total four minutes was 2.2 miles the average rate for each of the four minutes was 0.55 miles per minute. (It may be noted that in each of the four minutes the auto may not have traveled exactly 0.55 miles. There was an acceleration period and a slowing down period so that the rate is the average of the total time).

Graph #2

A careful record was kept of 10-second intervals of speed as indicated on the speedometer of the auto, and the total miles driven. This graph shows the rate of acceleration and the rate of deceleration.

Adapted from High School Biology, BSCS Green Version, pp. 27-28. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

DAILY PERIODISM IN MARINE PLANKTON

PURPOSE

To illustrate the vertical migration of marine plankters, which demonstrates a type of daily periodism.

ACTIVITY MATERIALS

Poster paper for bulletin board
Colored construction paper
Paints or colored pencils

WHAT TO DO

Prepare a large poster showing the vertical migration of three marine plankters as illustrated in figure 1.* This may be shown as a flannel board demonstration or as a bulletin board display.

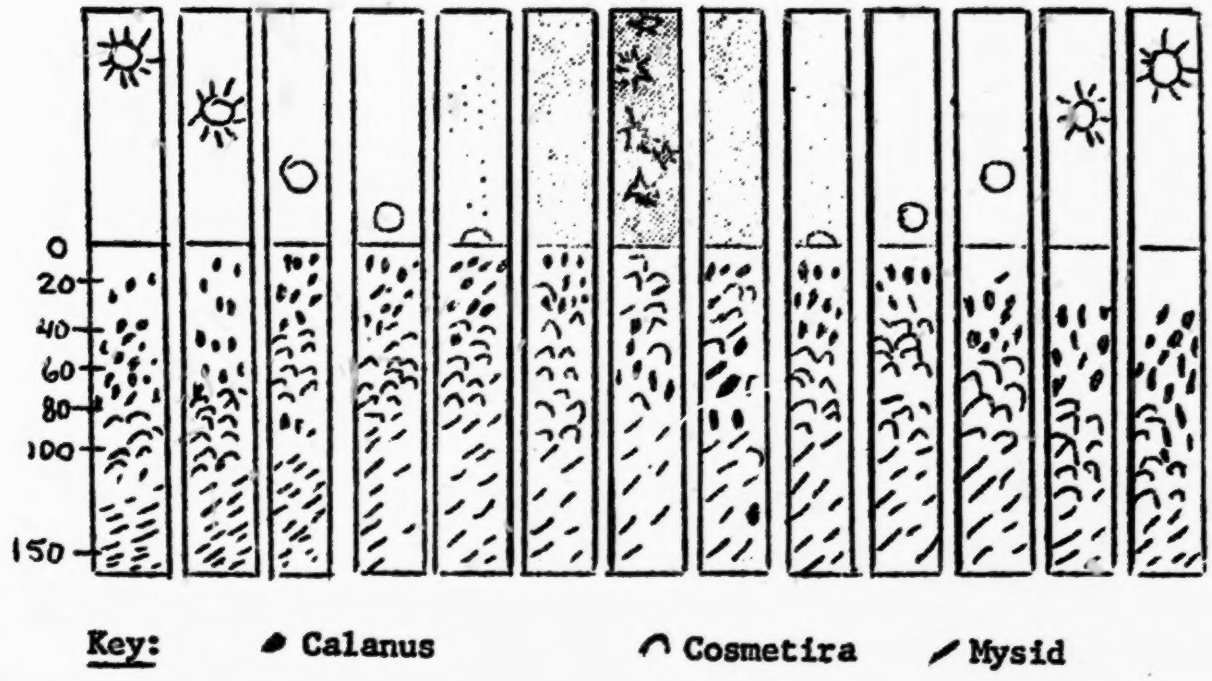


figure 1

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*Drawn after G. Simpson, et al., Life: An Introduction to Biology (New York: Harcourt, Brace, and World, 1957), p. 658. Permission granted by publishers.

UNIT THREE: DISTRIBUTION OF LIFE

ECOLOGICAL SUCCESSION IN A MICROENVIRONMENT

PURPOSE

To understand the concept of ecological succession as demonstrated by small aquatic environments set up in the laboratory.

ACTIVITY MATERIALS

One gallon battery jar (or wide-mouth mayonnaise jar)
Three one-quart jars or one-liter beakers
Glass plates to cover jars or beakers
Microscopes
Slides and cover slips
Graduated cylinder
Platform balance
Watch glass
Pipettes
Leaves and grass from a dried-up pond

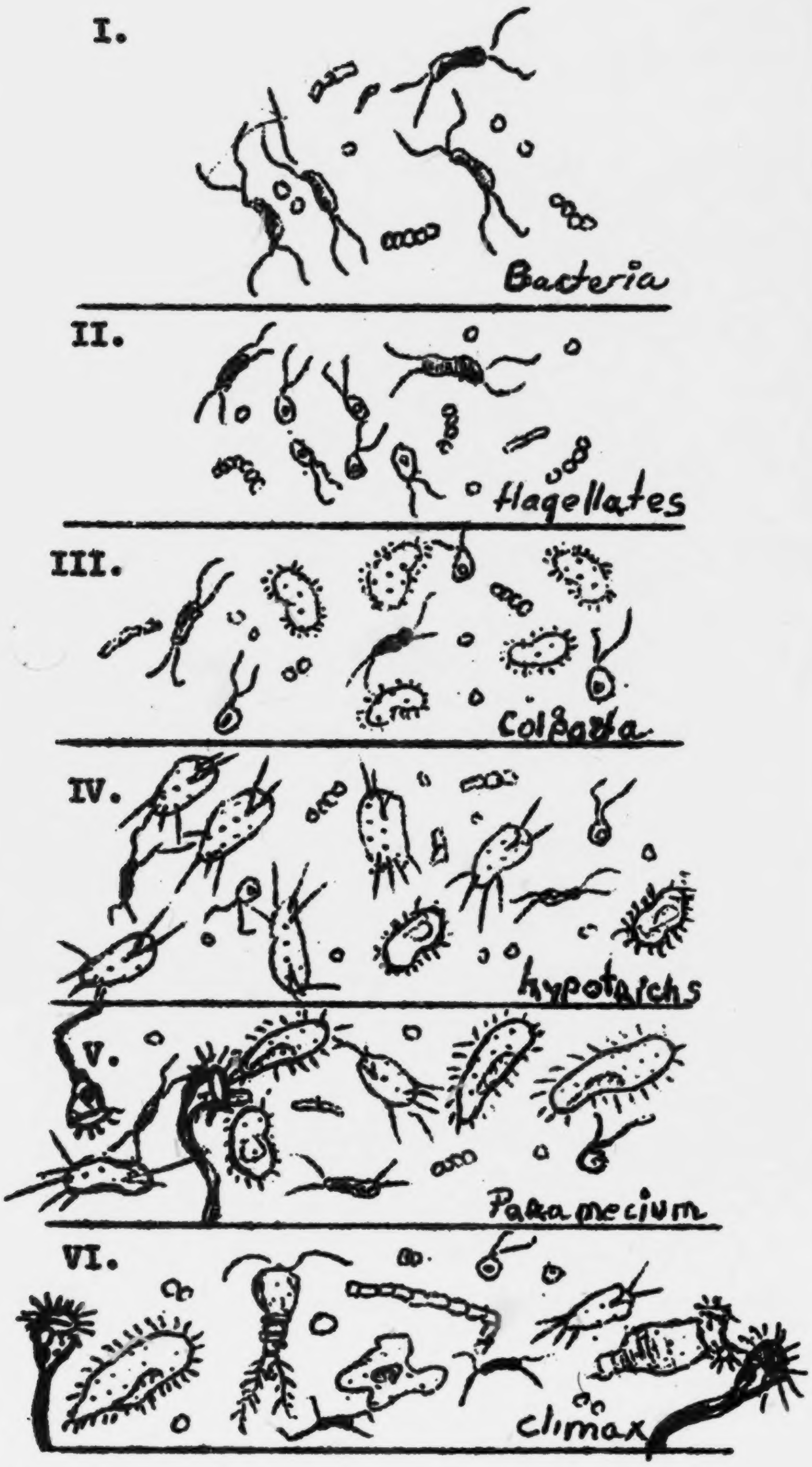
WHAT TO DO

Clean battery jar carefully with soap or detergent. Rinse the jar several times. Fill the jar half full of grass and leaves obtained from a dried-up ditch or pond or lake. Fill the jar with cool pond water that has been boiled. Put a glass plate on the jar. Place the jar in the room where the temperature varies the least.

Observe the culture every day. After four or five days look carefully for the appearance of scum or cloudiness, either on the surface of the water or in the jar on the leaves or grass. Examine a drop of this scum on a slide under low and high power of the microscope. What kind of organisms do you see? Can they move? What kind of motion, if any? How do they get their food?

Examine different parts of the culture every day from now on. Record and make sketches of any new organisms you may see. When the culture is 10 days old you should see some larger organisms. Make observations under the low and high power of the microscope. What kind of organisms do you see? Make a food chain diagram of your culture. Make a list of the ecological succession that has taken place in your culture jar.

PROTOZOAN SUCCESSION



I. Pioneer stage. Bacteria enter from the air (or from a seeding of pond water) and multiply rapidly. This is often characterized by a cloudy medium.

II. Monad flagellates are the first protozoans to appear. Bacteria remain in culture, but not in such great quantities.

III. Ciliate protozoans of genus Colpoda rise as the flagellates decline. Some bacteria and some flagellates remain.

IV. Hypotrich ciliates now grow in the medium, which has become unfit for maximum growth of Colpoda, but a few Colpoda remain.

V. Paramecia and stalked ciliates, Vorticella attain prominence as the hypotrichs decrease in numbers.

VI. Climax stage. A balanced microcosm of green algae, rotifers, crustaceans, and amebas is present, but a few representatives of each preceding stage remain.

TEMPORARY POND SUCCESSION

PURPOSE

To learn some basic understandings in succession of living organisms in a temporary pond.

ACTIVITY MATERIALS

Ditto sheets of drawings and questions given on pages 248-251
Reference books and textbook reading. Suggested supplementary book--
Basic Ecology, Ralph and Mildred Buchsbaum, Pittsburgh, Pa.: Boxwood Press, 1961, pp. 108-112.

WHAT TO DO

Answer questions on ditto sheets given on pages 248-251. Discuss a temporary pond succession after reading excerpts of reference given above.

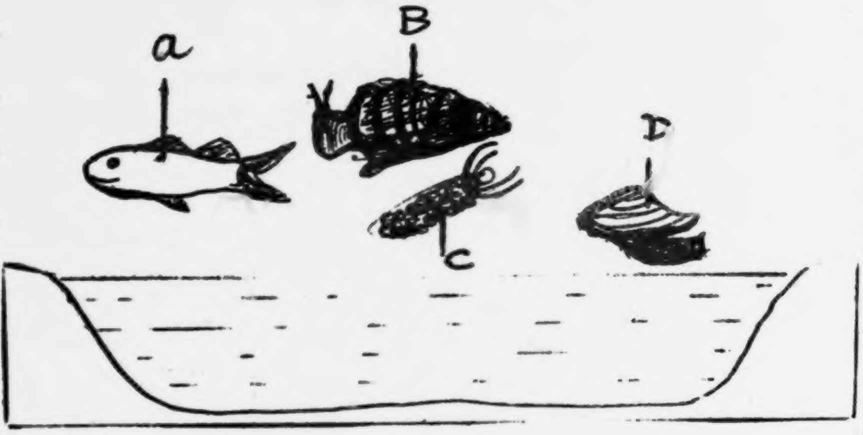
Place animals in figure 1 in appropriate sections of pond. Label the animals in the first stage of this succession.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________



Bare bottom

Pioneer State

figure 1

The bottom of this pond is in a bare bottom stage. Which animals in this stage are dependent on this type of soil? What is the soil type?

What is the source of food for organisms a., b., c., and d.?

How does the caddisfly larva build its peculiar house?

TEMPORARY POND SUCCESSION

Place animals in figure 2 in appropriate sections of pond.

Label the animals in the second stage of this succession.

a.________________________
b.________________________
c.________________________
d.________________________
e.________________________
f.________________________
g.________________________

What causes the "layer" of material on the bare bottom of the pond?

What organisms are now growing in the submerged vegetation stage which did not appear in the pioneer stage?

Which organisms are now growing in the submerged vegetation stage? Can you give some valid reasons for this?

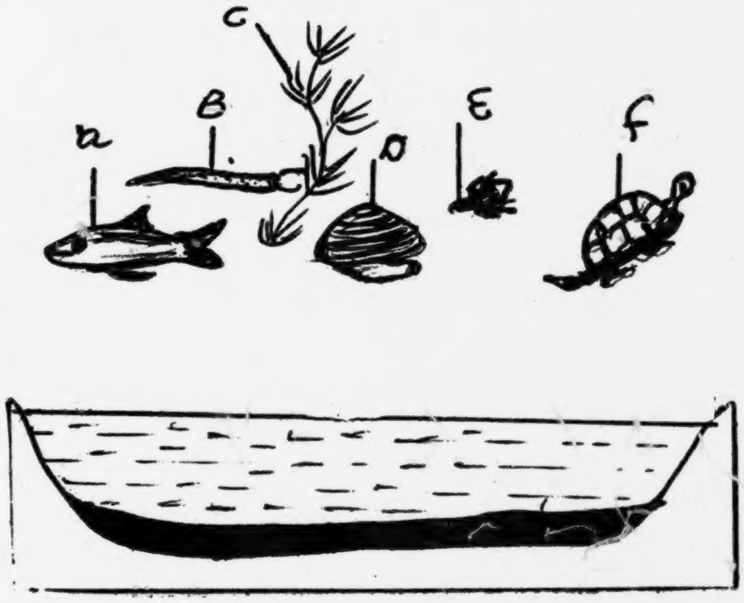


figure 2
Submerged vegetation stage

Why are more nesting fish and insects found in this type of pond?

Place animals in figure 3 in appropriate sections of pond.

Label the organisms in the third stage of this succession.

a.________________________
b.________________________
c.________________________
d.________________________
e.________________________
f.________________________
g.________________________
h.________________________
i.________________________

What new types of plants are found in this emerging vegetation stage?

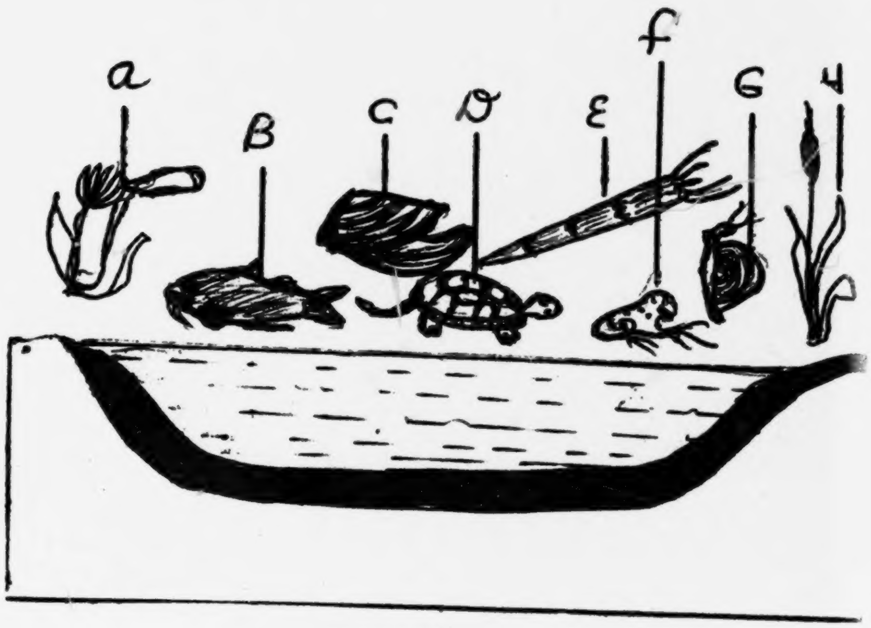


figure 3

Emerging vegetation stage

TEMPORARY POND SUCCESSION

With the increase of stagnant, vegetation-choked pond organisms, is there a decrease or an increase in the oxygen supply available to all forms of life in the pond? What kind of adaptations have certain animals developed for living under these conditions?

Are there any animals in this stage that require a dry support at some time in their lives? If so, which ones?

Place animals and plants in appropriate sections of diagram for figure 4.

Label the organisms in the fourth stage of this succession.

a.________________________
b.________________________
c.________________________
d.________________________
e.________________________
f.________________________
g.________________________
h.________________________
i.________________________

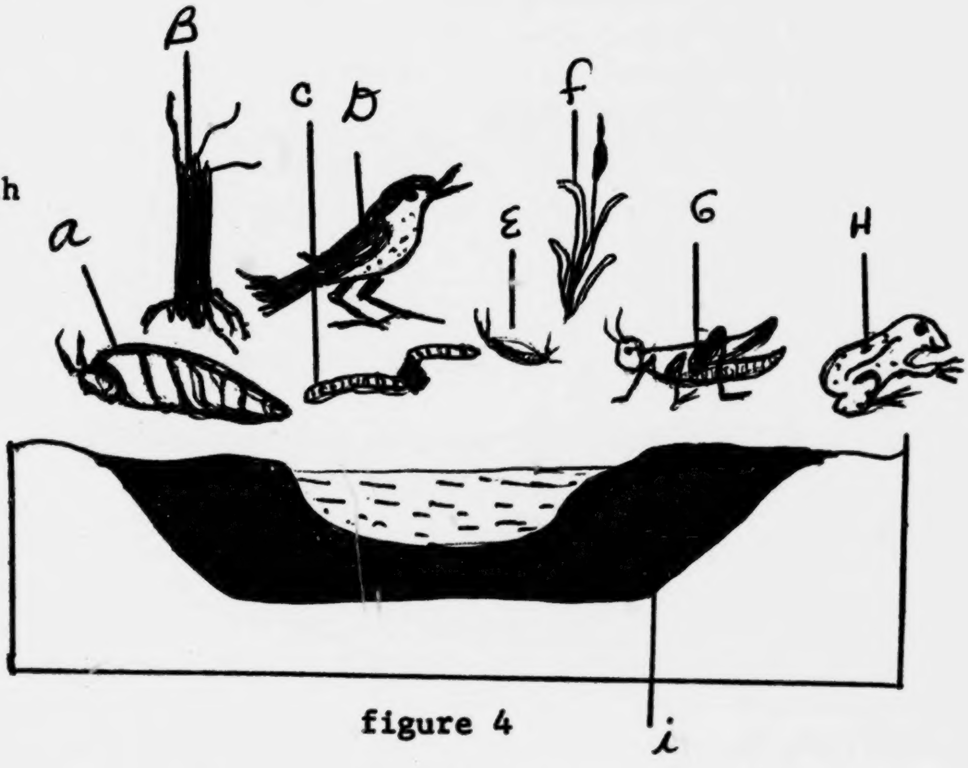


figure 4

Temporary pond and prairie stage

What has happened to the water level? Why?

Would the organisms in this stage be different during the winter and summer months? If so, why?

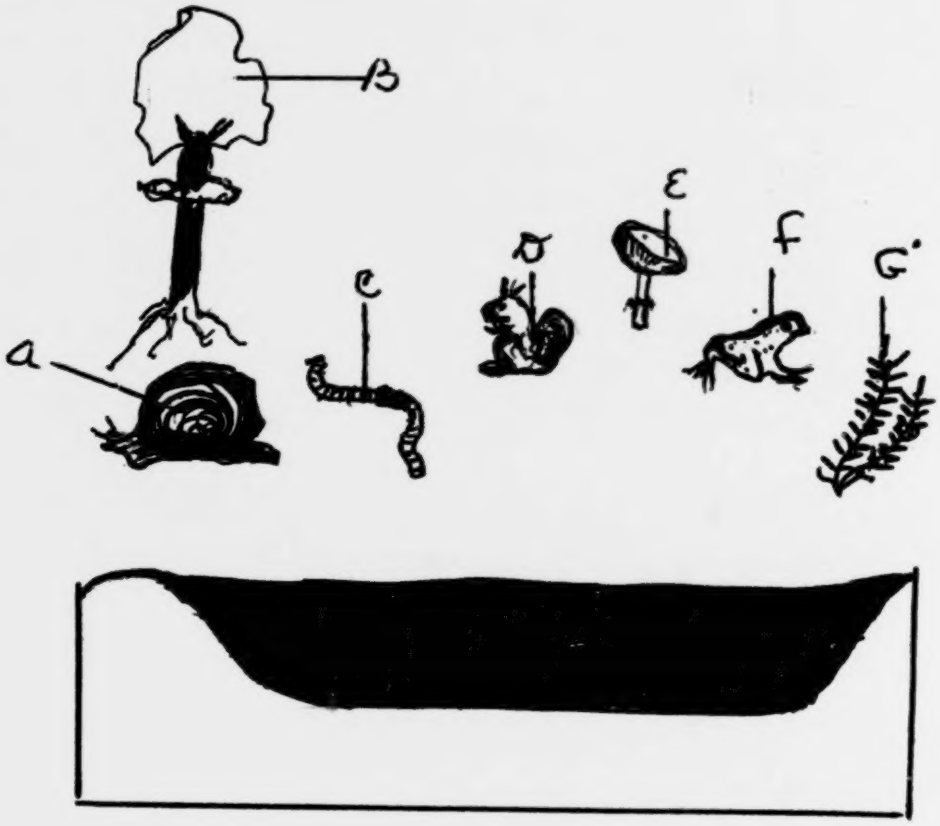
Fairy shrimp live mostly in small temporary ponds. Give an explanation for this specific niche.

TEMPORARY POND SUCCESSION

Place plants and animals in appropriate sections of diagram for figure 5.

Label the animals in the fifth stage of succession.

a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________
f. ____________________
g. ____________________



Beech-maple forest
Climax stage

figure 5

Beech-maple forest is considered to be the climax stage. What other plants in this geographical area would immediately precede the beech-maple forests?

If this were a climax stage in the dry prairie, what type of plants would represent this stage?

SAND DUNE SUCCESSION

PURPOSE

To learn some basic understandings about succession of living organisms in a sand dune.

ACTIVITY MATERIALS

Ditto sheets of drawings and questions
Reference books and textbook reading. Suggested supplementary book Basic Ecology, Ralph and Mildred Buchsbaum, Pittsburgh, Pa.: Boxwood Press, pp. 113-122.

WHAT TO DO

Students answer questions on ditto sheets.
Discuss the sand dune succession after doing the exercise and reading the supplementary pages suggested above.

Label the drawing in figure 1.

a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________

What is the area encompassed by a called? What kind of animals would be found in this area?

Decaying plants and animals form a layer of what? (Indicate label in drawing as part of answer.)

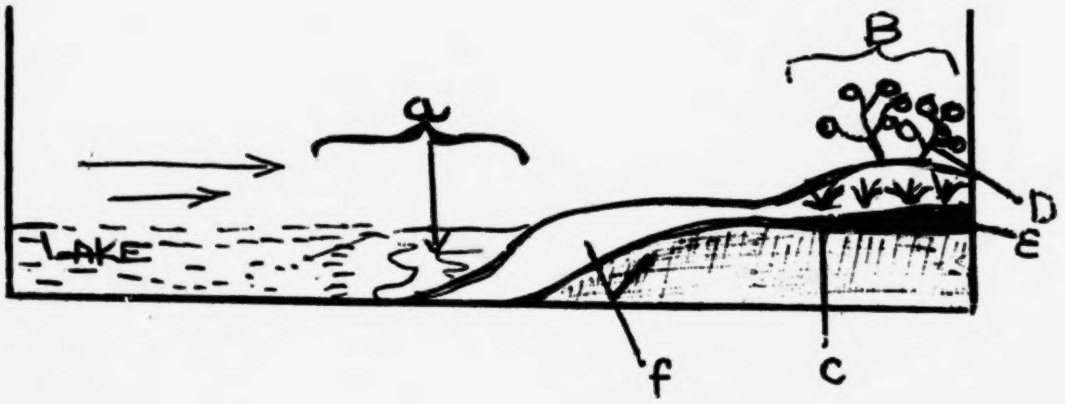


figure 1

UNIT THREE: DISTRIBUTION OF LIFE

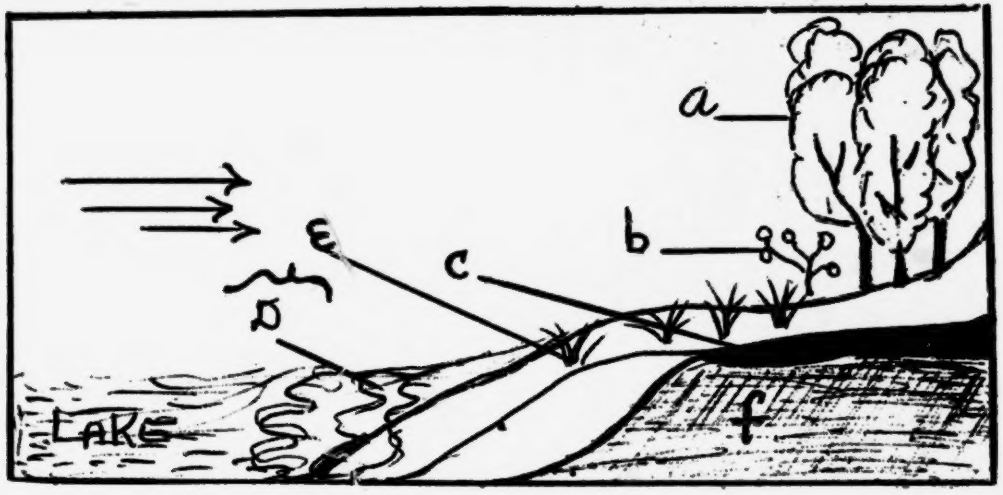
SAND DUNE SUCCESSION

Winds pile the sand dunes high up on the middle beach, but small perennials begin to bind the sand. Label the drawing in figure 2.

a. ____________________ d. ____________________
b. ____________________ e. ____________________
c. ____________________ f. ____________________

What does the growth of the cottonwood trees indicate?
Besides the binding power of certain sand grasses, what other factor plays an important part in moving decayed organisms below the sand?
What kinds of animals may find their homes in the cottonwood trees?
List insects that may be found from the wet margin up through the cottonwood stage.

figure 2



Label the diagram in figure 3.

a. ____________________ d. ____________________
b. ____________________ e. ____________________
c. ____________________ f. ____________________

What new kinds of plants appear after the cottonwood trees?
Make a list of the types of animals you might see in this new succession.
What major characteristics would the animals of this succession have? Why?
Are there many shrub-type plants in this stage? Which ones are most noteworthy?

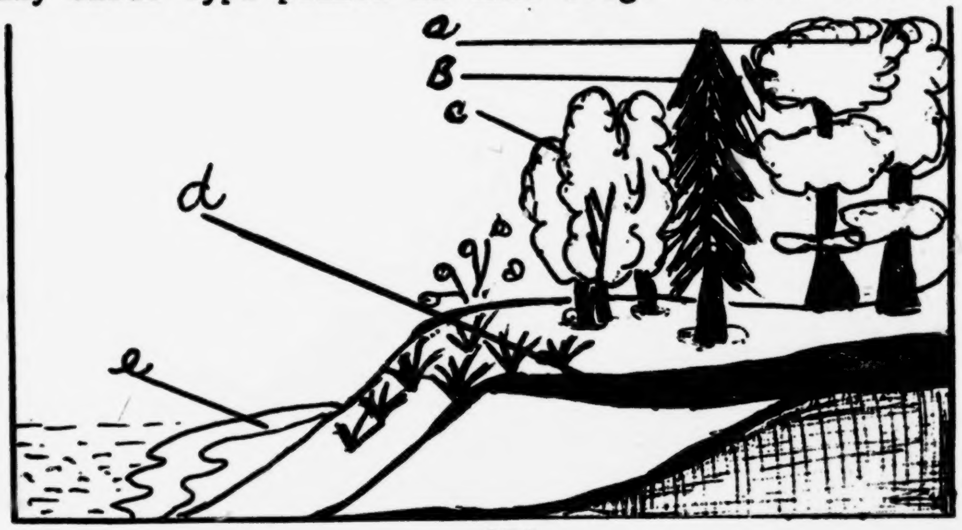


figure 3

SAND DUNE SUCCESSION

Label the drawing in figure 4.

a. ____________________________
b. ____________________________
c. ____________________________
d. ____________________________
e. ____________________________
f. ____________________________

Make a list of the plant succession from the dune through to the maple-beech climax.
What type of conditions are necessary for the maple-beech climax?
What kind of insects may be found in this climax community?

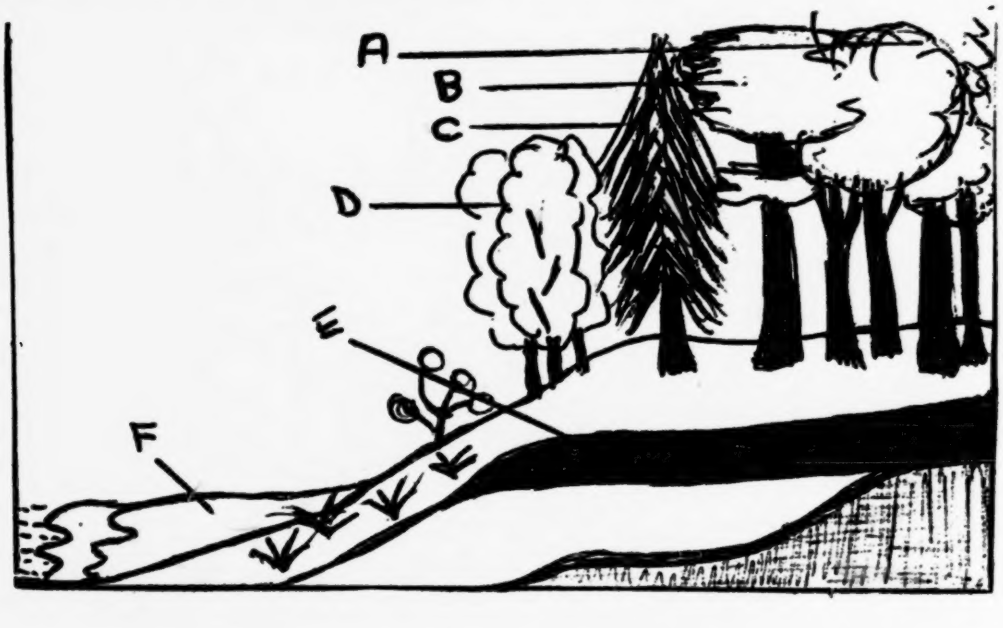


figure 4

PLANT SUCCESSION

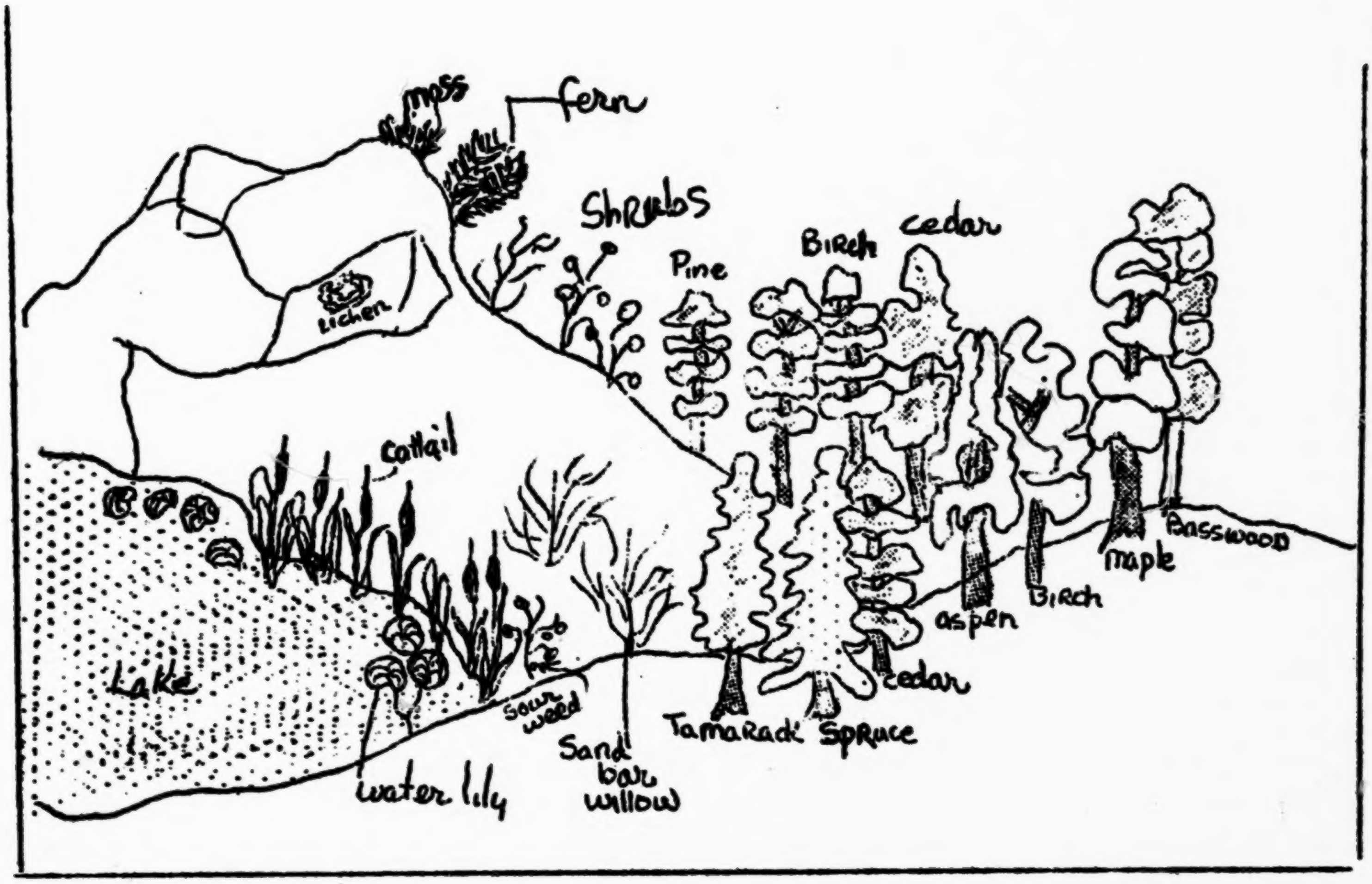
PURPOSE

A design for a bulletin board display.

ACTIVITY MATERIAL

Design

WHAT TO DO


moss
fern
Shrubs
lichen
Birch
cedar
Pine
cattail
Basswood
maple
Birch
aspen
cedar
Lake
sour weed
Tamarack
Spruce
Sand bar willow
water lily

Drawn after Elliott, Alfred M. Zoology, 3rd Edition, 1963, page 139, Fig. 5.17, Appleton-Century-Crofts. (Copyright © by Meredith Publishing Company.) By permission of Appleton-Century-Crofts.

UNIT THREE: DISTRIBUTION OF LIFE

CONCEPTS TO CONSIDER

Radiation received by the earth's surface is greatest around the middle and decreases rapidly toward the poles.

The amount of solar radiation received is the key environmental factor for living organisms.

Solar radiation is unequally received on the earth's surface.

Warm air will hold more water than cold air.

Water warms and cools very slowly, while land cools and warms relatively rapidly.

Cool air is denser than warm air and thus relatively "heavier" and tends to sink.

In the mid-latitudes (most of the United States) the air moves mainly from the west and in these mid-latitudes there is almost always a disturbance of the westerly pattern by alternating bulges of cold air from the north and warm air from the south.

The rotation of the earth causes wind currents to be deflected from their original paths of flow.

The actual picture of precipitation over the earth depends not only on the grand scheme of air circulation, but on the details of warm and cold ocean currents, on the distribution of land masses, and on the pattern of mountain chains, which, by forcing air masses upward, cools them off.

There is generally rising air over a warmer region and descending air over a cooler region.

The shape and the position of the earth in relation to the solar system result in a simple fact: that solar radiation is unequally received on the earth's surface.

Organisms are affected directly by energy values, intensity, and wave length, including associated aspects of color.

A substratum is a solid surface to which any organism attaches itself, or on which it rests or moves freely.

An organism that has become well adapted to a specific type of substratum is limited in its distribution by the availability of that substratum.

Organisms differ in their ability to tolerate ranges of temperature.

The penetration of light into the ocean determines the depth at which green plants may grow.

Light affects animals directly as they perceive their prey or detect their enemies through the sense of light.

Living organisms are limited in their distribution and in the success they attain by their limits of tolerance for various environmental factors such as: water, light, chemicals, substratum, temperature, heat, pH, gravity, pressure, sound, radiations, currents of air and water.

TEACHING APPROACH (Methods and Activities)

Discuss radiations as a characteristic of the physical environment
- -List the major radiations that reach the planet earth.
- -Briefly discuss the two theories of radiating units, as in waves or in particles.
- -Prepare a bulletin board display showing the types of radiations and their wave lengths.
- -Discuss absorption of radiations by the earth's atmosphere.
- -Discuss the "greenhouse effect", scattering and reflection brought about by dust particles in the atmosphere.
- -Students learn about radiation patterns by doing laboratory exercise on pp.264-265.
- -Demonstrate the angle of incidence by using a flashlight and a world globe.
- -Discuss insolation at different points on the earth at the same time.

Discuss the currents of air and water as a characteristic of the physical environment.

- -Students prepare a profile of planetary air circulation patterns.
- -Students prepare a world map showing the various ocean currents, using blue pencil to indicate cold currents and red pencil to indicate the warm currents.
- -Discuss the effects of various wind patterns the world over and also the patterns of ocean currents.
- -Discuss the tides.
- -Prepare a flannel board demonstration or give a chalk talk showing the differences between the spring tides and the neap tides.
- -Discuss wave action and the cause of waves.

UNIT THREE: DISTRIBUTION OF LIFE

Discuss the temperature as a characteristic of the physical environment
-Prepare a bulletin board display with thermometer suggested on page 266. Students bring new information to be placed at the appropriate place near the thermometer.
-Discuss the difference between poikilothermic animals and homoiothermic animals
-Students are assigned to report on the temperatures at which poikilothermic animals are most active and the same for homoiothermic animals
-Discuss aestivation, hibernation, and dormancy as related to temperature
-Prepare a list of living organisms (with the aid of class) on the chalk board that exhibit any one of the three qualities listed above, such as aestivation, hibernation, or dormancy.
-Students investigate the relation of temperature on some body functions; see suggested exercise on pp. 269-270.
-Discuss the Bioclimatic rule: "In spring and summer in temperate latitudes periodic phenomena, such as beginning of blossoming for a given species, ripening of fruit, or appearance of active insects, usually come three or four days later for each higher degree of latitude and for each 100 to 130 meters of latitude from any given base."*

Discuss light as a characteristic of the physical environment
-Discuss the effect of light on various living organisms. See pp.272-273.
-Discuss photoperiodicity in plants and animals. Ask students to find examples of plants and animals that show long-day reactions, short-day reactions, and those that are not affected at all.
-Discuss bioluminescence in the deeper waters of the ocean.
-Students report on the relationship of light to the coloration, size of eyes and vision in various living organisms found in the ocean and on land.

Discuss gravity, pressure and sound as characteristics of the physical environment.
-Students demonstrate the effects of gravity on living organisms. See pp.275-276 for suggested experiment.
-Discuss tropisms in plants and animals
-Discuss pressure changes and their effects on divers, seals, whales, and other living organisms
-Discuss pressure exerted on deep sea organisms
-Prepare a bulletin board to show the range of pressure tolerances in various living organisms
-Discuss effects of sound on living organisms

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*W. C. Allee, et al., Principles of Animal Ecology (Philadelphia, Pa.: Saunders, 1949), p. 117. By permission of publishers.

- Assign some students to report on the use of sound by bats.
- Assign some students to locate the sound tolerance range for various living organisms.

Discuss substratum as a characteristic of the physical environment.

- Make a list of the various types of substrates to be considered, such as water, ooze, mud, sand, rocky, clay, loam, and others.
- Discuss burrowing animals and adaptations of animals to various land surfaces.
- Discuss the effect of pH of soils on living organisms. Students may wish to test various soils for the range of pH.

Discuss water as a characteristic of the physical environment.

- Students do laboratory experiment to illustrate the effect of water on seed germination. See p. 274.
- Review the water cycle.
- Discuss the effect of little or no water on plants and animals.
- Discuss the effect of too much water available to plants and animals.

DEPTH PROBE

- GEOGRAPHY OF RADIATION PATTERNS, pp. 264-265 (Average Student Basic Activity)--To understand that it is possible to distinguish patterns of radiation according to the geographic location and time of year. Students work individually.

- TEMPERATURE--OPTIMUM, MAXIMUM, AND MINIMUM, p. 266 (Average Student Basic Activity--Optional)--To illustrate the principle of optimum, maximum, and minimum temperatures upon living organisms. Students work individually or bulletin board display.

- TEMPERATURE AND RAINFALL, pp. 267-268 (Average Student Basic Activity)--To learn that temperature and rainfall patterns are limiting factors in distribution of plants and animals. Students work individually.

- TEMPERATURE AFFECTS THE HEART BEAT OF DAPHNIA, pp. 269-270 (Average Student Basic Activity--Optional)--To determine the relationship of temperature on the rate of heartbeat in Daphnia. Students work in pairs.

- GENERAL STRUCTURE OF THE ATMOSPHERE, p. 271 (Average Student Basic Activity--Optional)--A design for a bulletin board display. Teacher demonstration.

- EFFECTS OF LIGHT ON LIVING ORGANISMS, pp. 272-273 (Average Student Basic Activity--Optional)--To learn about some responses of living things to various light intensities and color. Students work in groups.

UNIT THREE: DISTRIBUTION OF LIFE

- EFFECTS OF GRAVITY ON LIVING ORGANISMS, pp. 275-276 (Average Student Basic Activity)--To learn and understand some of the responses of living things to the force of gravity. Students work in groups.

- EFFECTS OF THE ENVIRONMENT ON THE TRANSPIRATION RATE IN PLANTS, pp. 277-278 (Average Student Basic Activity)--To understand that the transpiration rate is due to varying conditions of the environment. Students work in groups.

- THE EFFECT OF WATER ON GERMINATION OF SEEDS, p. 274 (Average Student Basic Activity)--To learn the best soaking period necessary for germination. Minimum, maximum, and optimum conditions. Students work in groups.

"TOOLS" FOR EXTENDING CONCEPTS

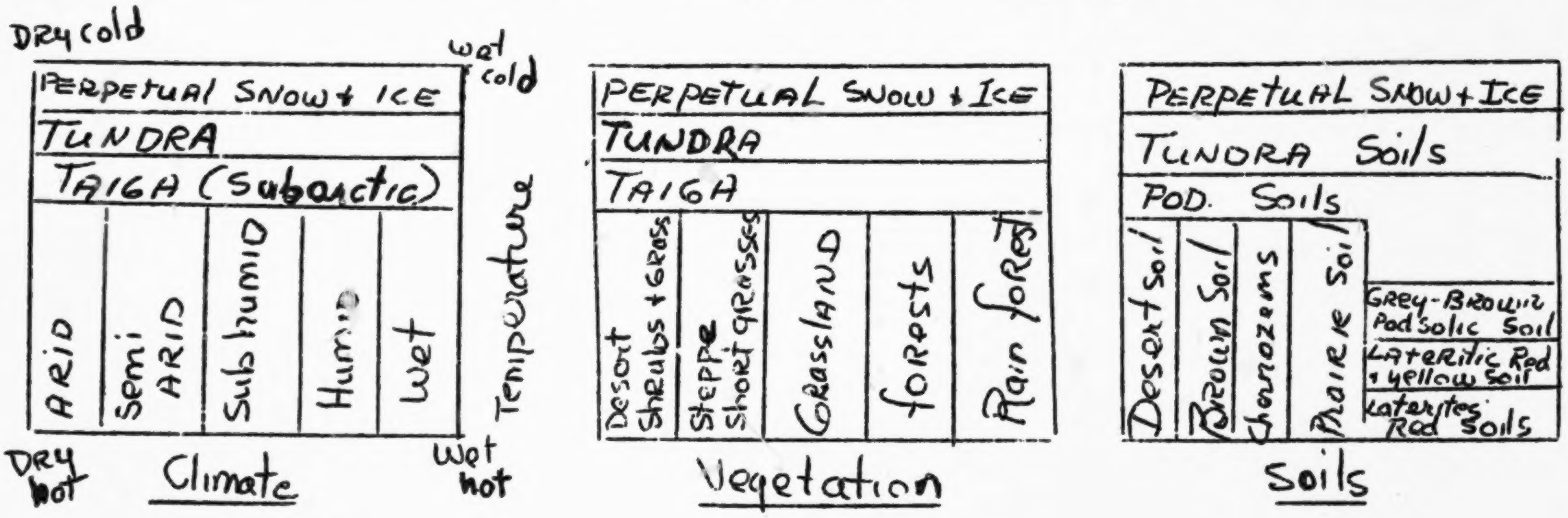
- Plan to show films:
  "The Nature of Light" Fsd 535-2
  "Gravity" Fsd 531.5-1

- Plan to show filmstrips:
  "Meteorology" S-8 Sets 1-3
  "The Face of the Land" S-127 Set 1
  "The Miracle of the Sea" S-126 Set 1
  "Earth and Its Wonders" S-79 Sets 1-6
  "Seasons, Weather, and Climate" S-108 Set 1

- Encourage students to prepare a bulletin board display on EARTH'S OCEANS: AIR AND WATER.
- Assign some student group to make a visual presentation and an oral report on the topic REASONS FOR SEASONS.
- Encourage students to make a written report on the effects of sound on a variety of living organisms.
- Assign students to make a survey of types of substrata and adaptations of substrata at the seashore and the living organisms in each.
- Encourage students to report on the ability of bats to use sound for their means of sight. Investigate the difference between larger bats and smaller bats as to their abilities to maneuver equally in a similar situation.
- Assign some students to report on bioluminescence. Encourage students to prepare a list of those animals that show this characteristic.
- Encourage students to read about photoperiodicity in plants and animals.
- Assign a student group to experiment with various soils to investigate pH ranges and water retention capacity.

UNIT THREE: DISTRIBUTION OF LIFE

-Prepare a poster to show the interrelationships of climate, vegetational formations and zonal soil groups as in example shown below:*


DRY cold
wet cold
PERPETUAl SNOW + ICE
TUNDRA
TAIGA (Subarctic)
ARID
Semi ARID
Sub humid
Humid
Wet
Temperature
DRY hot
wet hot
Climate
PERPETUAL SNOW + ICE
TUNDRA
TAIGA
Desert Shrubs + Grass
Steppe Short grasses
Grassland
forests
Rain forest
Vegetation
PERPETUAL SNOW + ICE
TUNDRA Soils
POD. Soils
Desert Soil
Brown Soil
Chernozems
Prairie Soil
Grey-Brown Podsolic Soil
Lateritic Red + yellow Soil
Laterites Red Soils
Soils

- Ask students to locate information on a "cricket thermometer" and report to class
- Assign students to prepare a list of plants that grow in Southern California but are limited by extremes of temperatures
- Encourage some students to read Scientific American articles: Bernstein, J. Tsunamis August, 1954, and Bascom, Willard Ocean Waves August, 1959
- Ask a student group to report on the topic of animal distribution by wind
- Encourage some students to investigate pelage and plumage changes in organisms due to light exposure of varying lengths.

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*Eugene Odum, Fundamentals of Ecology (Philadelphia, Pa.: Saunders, 1959), p. 134. By permission of publishers.

UNIT THREE: DISTRIBUTION OF LIFE

PLANNING AHEAD

-Make preparations for construction of habitat terraria as suggested on p. 322.
-Order commercial rhizobium inoculum powder for experiment with nitrogen fixing bacteria
-Review information on procedures for building dioramas.
-Order exhibits from Instructional Materials Center such as: "Bivalves", Set 1; "Corals", Set 1; "Crustaceans", Set 1; "Echinoderms", Set 1; "Univalves", Set 1
-Order exhibits of birds of various biomes. See 1961 Catalog of Audio-Visual Secondary Grades, pp. 139-144, pub. 579.
-Make plans for a field trip to the La Brea Tarpits. See pp. 41-43 in Part I of this Instructional Guide.
-Start a saltwater aquarium.
-Encourage some students to make seashore fieldtrip for collecting tide pool animals for the saltwater aquarium.
-Make preparations to start a Drosophila culture for Unit Four.
-Order "Habitat Map of California" S-18 from Instructional Materials Center if not in school science department.
-Encourage students to bring their own sets of slides to show classmates pictures taken of desert, mountain, seashore, and others....especially animals and plants of the various biomes.
-Order green hydra and green Paramecia from the Science Center on the fresh materials order.
-Locate a source of live termites.
-Order live frogs or assign some students to make collections from nearby streams or lakes.
-Encourage some students to make collections of lichens and mushrooms for class display.
-Assign some student to grow bread mold and fruit mold for classroom observation.
-Try to locate pictures of warblers as suggested on p. 299.
-Order Paramecium aurelia and Paramecium caudatum from Science Center.

UNIT THREE: DISTRIBUTION OF LIFE

BROADENING "CONTENT HORIZONS"

Teacher References:

Articles from Scientific American
Gamow, George. "Gravity," (March, 1961)
Heiskanen, Weikko. "The Earth's Gravity," (September,1955)
Kellog, Charles. "Soil," (July, 1950)
Sayre, A. N. "Ground Water," (November, 1950)
Buswell, Arthur and Worth Rodebush "Water," (April, 1956)
Munk, Walter. "The Circulation of the Oceans," (September, 1955)
Wexler, Harry. "Volcanoes and World Climate," (April, 1952)
Plass, Gilbert. "Carbon Dioxide and Climate," (July, 1959)
Landsberg, Helmut. "The Origin of the Atmosphere," (August, 1953)
Bascom, Willard. "Ocean Waves," (August, 1959)
Emiliani, Cesare. "Ancient Temperatures," (February, 1958)
Woodcock, A. H. "Salt and Rain," (October, 1957)

Allee, W.C., et al. Principles of Animal Ecology. Philadelphia: W.B. Saunders Co., 1949.
Henderson, L. J. The Fitness of the Environment. New York: Macmillan, 1913.
Clarke, G. L. Elements of Ecology. New York: John Wiley, 1954.
Odum, E.P. Fundamentals of Ecology. Philadelphia: W. B. Saunders Co.,1959
Simpson, G., et al. Life: An Introduction to Biology. New York: Harcourt,Brace, 1957. (Title III-Collection)
Defant, Albert. Ebb and Flow: The Tides of Earth, Air and Water. Ann Arbor, Michigan: University of Michigan Press, 1958.
Stumpff, Karl. Planet Earth. Ann Arbor, Michigan: University of Michigan Press, 1959.

Student References:

Articles from Scientific American listed above
Leopold, Alde. A Sand Country Almanac. Fairlawn, New Jersey: Oxford University Press, 1949.
Franklin, Thomas. Climates in Miniature. London: Faber, 1955.
Benton, Allen, and W. E. Werner. Principles of Field Biology and Ecology. New York: McGraw-Hill, 1958. (Title III-Collection)
Buchsbaum, Ralph and Mildred. Basic Ecology. Pittsburgh, Pennsylvania: Boxwood Press, 1957.
Storer, J. Web of Life. New York: Mentor Book, 1953.

UNIT THREE: DISTRIBUTION OF LIFE

GEOGRAPHY OF RADIATION PATTERNS

PURPOSE

To understand that it is possible to distinguish patterns of radiation according to the geographic location and time of year.

ACTIVITY MATERIALS

A world atlas
Textbook information on radiation patterns

WHAT TO DO

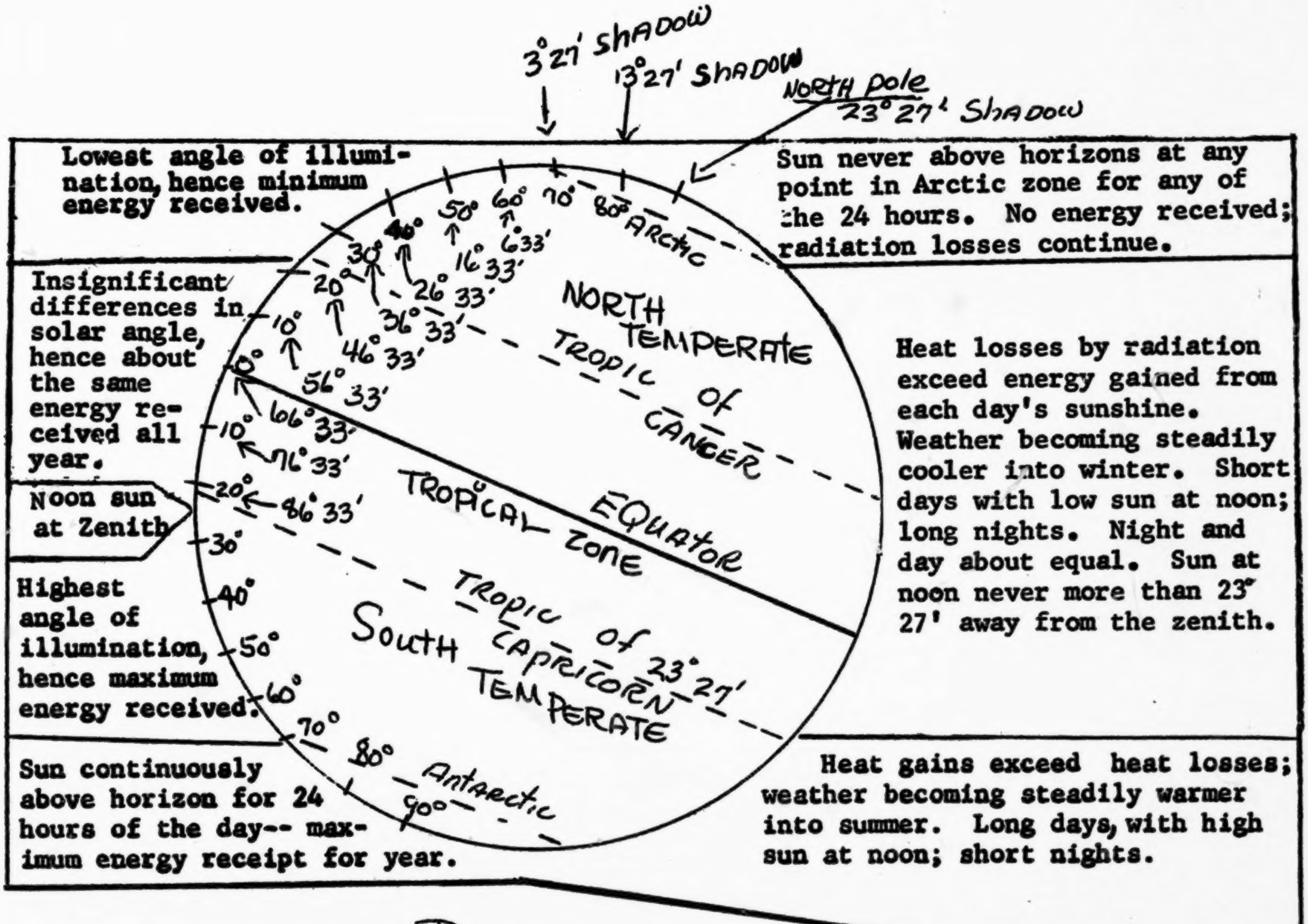
Refer to an atlas for the latitudes of the cities listed. Consider the position of the sun at the stated dates and times. As you obtain the necessary information, rearrange the cities in each group in the order of decreasing insolation. Insolation means the hours of sunshine each day and the angle of incidence.

Noon at the June solstice (sun over Tropic of Cancer): Winnipeg, Canada; New Orleans, Louisiana; Rio de Janeiro, Brazil; Havana, Cuba; Caracas, Venzuela; Boston, Massachusetts.

Noon at the December Solstice (sun over the Tropic of Capricorn): Singapore; Hobart, Tasmania; Tokyo, Japan; Manila, Republic of Philippines; Brisbane, Australia; Canton, China.

Noon at the equinoxes (sun over equator): Tananarive, Madagascar; Capetown, South Africa; Madrid, Spain; Nairobi, Kenya; Cairo, Egypt; Copenhagen, Denmark.

Taken from High School Biology, Green Version - The Laboratory, Part One, Exercise 6.1, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.


3°27' SHADOW
13°27' SHADOW
North pole
23°27' Shadow
40°
50°
60°
70°
80°
ARCTIC
30°
20°
10°
0°
6°33'
16°33'
26°33'
36°33'
46°33'
56°33'
66°33'
76°33'
86°33'
NORTH TEMPERATE
TROPIC OF CANCER
EQUATOR
TROPICAL ZONE
TROPIC OF CAPRICORN 23°27'
SOUTH TEMPERATE
-10°
-20°
-30°
-40°
-50°
-60°
70°
80°
Antarctic
90°

Lowest angle of illumination, hence minimum energy received.

Sun never above horizons at any point in Arctic zone for any of the 24 hours. No energy received; radiation losses continue.

Insignificant differences in solar angle, hence about the same energy received all year.

Noon sun at Zenith

Highest angle of illumination, hence maximum energy received.

Heat losses by radiation exceed energy gained from each day's sunshine. Weather becoming steadily cooler into winter. Short days with low sun at noon; long nights. Night and day about equal. Sun at noon never more than 23° 27' away from the zenith.

Sun continuously above horizon for 24 hours of the day-- maximum energy receipt for year.

Heat gains exceed heat losses; weather becoming steadily warmer into summer. Long days, with high sun at noon; short nights.

December 21

Drawn after Lorus and Margery Milne, Biotic World and Man (Englewood Cliffs, N. J.: Prentice-Hall, 1958), p. 382. By permission of Prentice-Hall, Inc., publishers.

TEMPERATURE--OPTIMUM, MAXIMUM, AND MINIMUM

The Range of Differences

PURPOSE

To illustrate the principle of optimum, maximum, and minimum temperatures upon living organisms.

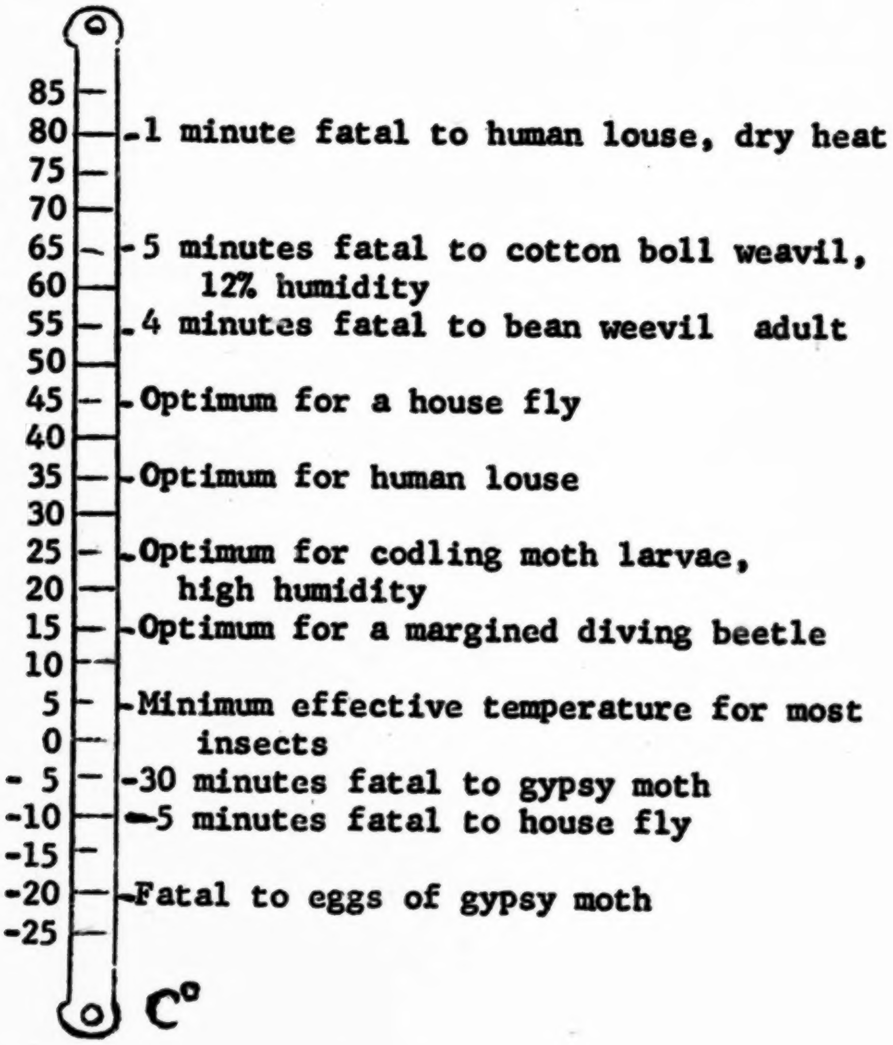
ACTIVITY MATERIALS

Ditto chart of temperature scale
Reference materials on effects of temperature on living organisms
Bulletin board display of thermometer and samples

WHAT TO DO

Prepare a bulletin board display showing the optimum, maximum, and minimum temperature tolerances of various living organisms.

Students prepare a chart of living organisms to show the effect of temperature intensities.


85
80 -1 minute fatal to human louse, dry heat
75
70
65 -5 minutes fatal to cotton boll weavil, 12% humidity
60
55 -4 minutes fatal to bean weevil adult
50
45 -Optimum for a house fly
40
35 -Optimum for human louse
30
25 -Optimum for codling moth larvae, high humidity
20
15 -Optimum for a margined diving beetle
10
5 -Minimum effective temperature for most insects
0
- 5 -30 minutes fatal to gypsy moth
-10 -5 minutes fatal to house fly
-15
-20 -Fatal to eggs of gypsy moth
-25
C°

Adapted from Fundamentals of Insect Life by Metcalf and Flint, 1937, McGraw-Hill in Fundamentals of Biology by Harbaugh et al, 1953. McGraw-Hill. p. 12. Used by permis

TEMPERATURE AND RAINFALL

PURPOSE

To learn that temperature and rainfall patterns are limiting factors in the distribution of plants and animals.

ACTIVITY MATERIALS

Data from representative places in some of the major biomes
Ditto sheets of unknown biomes showing only the temperature and rainfall
Graph paper

WHAT TO DO

Plot graphs of the following temperature and rainfall

	J	F	M	A	M	J	J	A	S	O	N	D	
T.	81	81	81	80	78	75	76	78	82	82	82	81	Tropical
P.	9.8	8.3	8.3	4.0	2.1	0.3	0.2	1.1	2.0	4.5	5.9	8.1	Forest
													(Fallon, Nevada)
T.	31	36	41	50	56	65	74	72	61	51	40	32	Desert
P.	0.6	0.5	0.5	0.4	0.6	0.3	0.1	0.2	0.3	0.4	0.3	0.6	
													(Santa Monica, Cal.)
T.	53	53	55	58	60	63	66	65	65	62	58	55	Scrub
P.	3.5	3.0	2.9	0.5	0.5	0.0	0.0	0.0	0.1	0.6	1.4	2.3	Forest
													(Moose Factory, Ontario)
T.	-4	-2	10	28	42	54	61	59	51	39	22	5	Taiga
P.	1.3	0.9	1.1	1.0	1.8	2.2	2.4	3.3	2.9	1.8	1.1	1.1	
													(Galveston, Texas)
T.	54	56	63	70	76	82	84	83	80	73	63	57	Coastal
P.	3.4	3.0	2.9	3.1	3.4	4.2	4.0	4.7	5.7	4.3	3.9	3.7	Prairie
													(Omaha, Nebraska)
T.	22	25	37	51	63	72	77	75	66	55	39	27	Tallgrass
P.	0.7	0.9	1.3	2.8	4.1	4.7	4.0	3.2	3.0	2.3	1.1	0.9	Midgrass
													(Winnipeg, Canada)
T.	-4	0	15	38	52	62	66	64	54	41	21	6	Prairie
P.	0.9	0.7	1.2	1.4	2.0	3.1	3.1	2.2	2.2	1.4	1.1	0.9	Aspen border

---

Taken from High School Biology, Green Version - The Laboratory, Part One, Exercise 6.2, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

TEMPERATURE AND RAINFALL

													(Dubuque, Iowa)
T.	20	23	35	49	60	70	75	72	64	52	37	25	Tallgrass
P.	1.5	1.4	2.2	2.6	3.9	4.5	3.7	3.4	4.0	2.5	1.9	1.5	Prairie
													(Goodland, Kansas)
T.	29	33	40	50	59	70	77	74	66	54	41	30	Midgrass
P.	0.3	0.6	1.0	1.8	2.5	2.8	2.7	2.5	1.6	1.0	0.6	0.6	Shortgrass
													(Laramie, Wyoming)
T.	21	22	29	38	46	55	62	62	52	41	30	22	Bunch
P.	0.5	0.3	0.8	1.0	1.5	1.2	1.7	1.2	1.0	0.9	0.5	0.5	Grass

Summarize the relationship between rainfall, temperature, and the different biomes given in the known biomes.

Plot graphs for the following unknowns and try to predict the type of biome suggested by the rainfall and temperature record.

Unknowns

	J	F	M	A	M	J	J	A	S	O	N	D
(a)T.	34	35	43	54	64	72	77	74	68	57	46	36
P.	3.2	3.0	3.5	3.3	3.6	3.9	4.4	4.0	3.1	3.1	2.5	3.1
(b)T.	51	52	54	58	60	67	70	71	68	62	57	52
P.	3.6	3.5	3.4	2.6	2.0	0.8	0.2	0.2	1.4	3.3	4.3	4.1
(c)T.	78	78	76	77	76	74	74	74	76	77	78	78
P.	10.2	9.8	12.2	6.5	10.0	7.4	6.6	4.6	8.7	7.2	8.4	11.5
(d)T.	55	59	65	70	77	85	91	90	84	72	61	56
P.	0.4	0.5	0.4	0.1	0.0	0.0	0.1	0.5	0.2	0.2	0.3	0.4
(e)T.	-8	-9	-6	6	25	35	41	41	34	25	14	1
P.	0.4	0.5	0.7	0.6	0.6	0.5	0.9	1.1	1.1	1.1	1.1	0.5

Note to the teacher:
Answers to the unknowns
(a) Temperate Deciduous Forest, Washington, D. C.
(b) Scrub Forest, Lisbon, Portugal
(c) Tropical Forest, Quitos, Peru
(d) Desert, Yuma, Arizona
(e) Tundra, Upernavik, Greenland

T-Temperature
P-Precipitation

DAPHNIA HEART BEAT AND TEMPERATURE

PURPOSE

To determine the relationship of temperature on the rate of heartbeat in Daphnia.

ACTIVITY MATERIALS

Thermometer
Beaker
Ice Water
Daphnia culture
Warm water bath
Watch with second sweep hand
Microscope
Slide and cover slip

WHAT TO DO

Place several Daphnia on a slide and observe the heartbeat, making a count of the beat for normal room temperature. Start the count and record the beat for a period of fifteen seconds. Multiply the number for this period by four to record the rate for one minute. Repeat this procedure for three times and take an average for the heart beat for normal room temperature. Record the average in chart on following page.

Place Daphnia culture in a beaker containing a warm water bath (37° C). Place the thermometer in the water containing the culture to be sure that it maintains the 37° C. Place several Daphnia on a slide and count the heart beat in the same manner as described above. Place the average for this in the chart on following page:

Place Daphnia culture in a beaker containing ice water (4° C). Place the thermometer in the water containing the culture to be sure that it maintains the 4° C temperature. Place several Daphnia on a slide and count the heart beat in the same manner described above. Place the average for this in the chart on following page:

What is the normal heartbeat of this animal? What is the effect of the changes in temperature on the rate of heart beat? How might this effect correlate with the availability of food in a natural environment?

Taken from High School Biology, Green Version - The Laboratory, Part Two, Exercise 13.8, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

ECOLOGICAL BIOGEOGRAPHY
PHYSICAL FACTORS

UNIT THREE: DISTRIBUTION OF LIFE

Temperature			Heartbeat of Daphnia	Members of team
4°C	Room Temp.	37°C		

Make a graph, plotting the rate of heartbeat against temperature.

UNIT THREE: DISTRIBUTION OF LIFE

GENERAL STRUCTURE OF THE ATMOSPHERE

PURPOSE

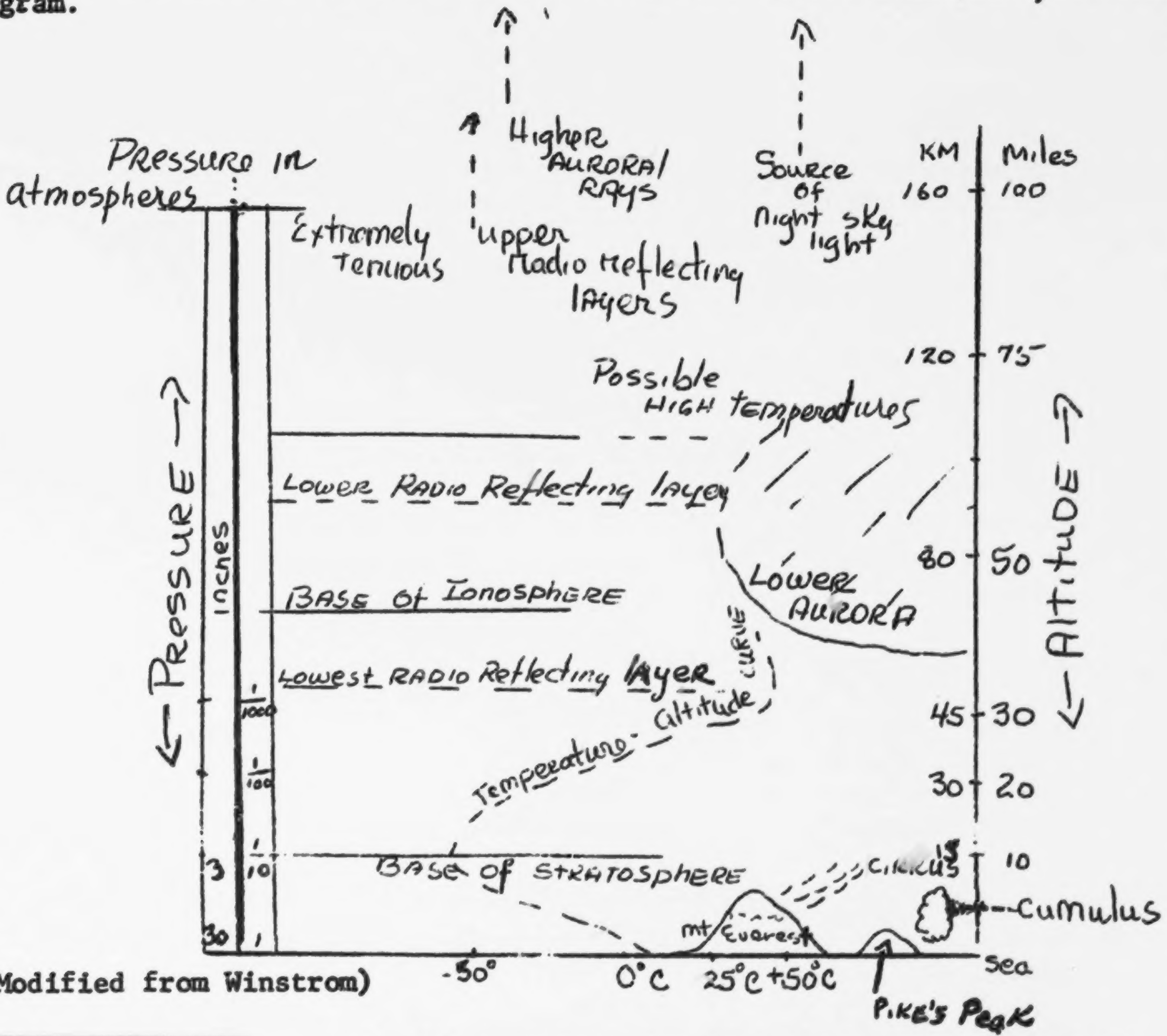
To illustrate through a bulletin board display the general structure of the earth's atmosphere.

ACTIVITY MATERIALS

Various colors of construction paper

WHAT TO DO

Prepare bulletin board display of general structure of the atmosphere, as shown in diagram.


Pressure in atmospheres
← Pressure →
Inches
3
30
1/1000
1/100
1/10
1
Higher Auroral Rays
Source of night sky light
KM
Miles
160
100
120
75
80
50
45
30
30
20
15
10
Sea
← Altitude →
Extremely Tenuous
Upper Radio Reflecting layers
Possible High temperatures
Lower Radio Reflecting layer
Lower Aurora
Base of Ionosphere
Lowest Radio Reflecting layer
Temperature-Altitude Curve
Base of Stratosphere
Cirrus
Cumulus
Mt Everest
Pike's Peak
-50°
0°C
25°C
+50°C

(Modified from Winstrom)

Drawn after W. C. Allee, et al., Principles of Animal Ecology (Philadelphia, Pa.: Saunders, 1949), p. 141. By permission of publishers.

UNIT THREE: DISTRIBUTION OF LIFE

EFFECTS OF LIGHT ON LIVING ORGANISMS

PURPOSE

To learn about some responses of living organisms to various light intensities and colors.

ACTIVITY MATERIALS

Radish seeds
Paper cups or small flower pots
Cellophane in various colors...blue, red, green, and yellow
Shoe boxes.

WHAT TO DO

Stand shoe box up on end and place paper cup containing germinating radish seedlings or flower pot in the box. Cut a rectangular hole in the shoe box cover so light will be admitted at a level just above the surface of the paper cup. Cover the rectangular opening with red cellophane.

Follow the same procedure with radish seedlings, but cover the opening in box two with blue cellophane.

Do the same for several other boxes, using green cellophane and yellow cellophane.

Prepare one shoe box without an opening and place radish seedlings in this environment.

Prepare a shoebox with an opening as above, but without a colored cellophane paper. Place radish seedlings in this environment.

Box #1 - Covered with red
Box #2 - Covered with blue
Box #3 - Covered with green
Box #4 - Covered with yellow
Box #5 - Completely light-tight
Box #6 - Opening to allow light in

Allow the radish seedlings to grow for a period of four to five days. Be sure to water each box of plants, being careful not to allow the plants to remain in the light for very long.

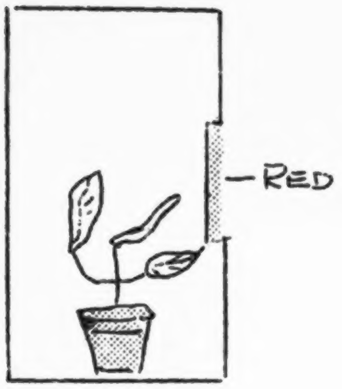
Which of the plants show an obvious change in direction of growth?

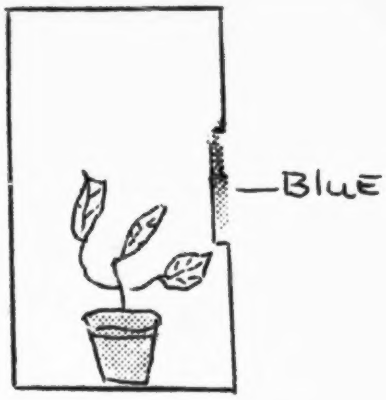
Is there any difference in the direction of growth of plants covered with blue cellophane, red cellophane, green cellophane, yellow cellophane?

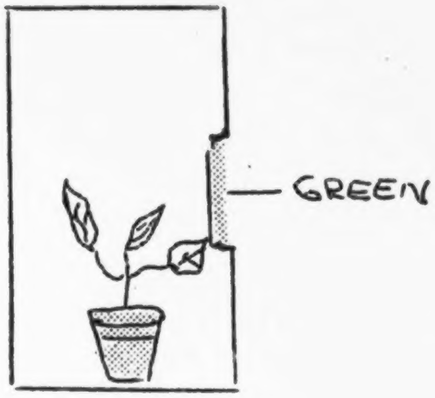
Is there any difference between plants grown in blue light and those grown in red light?

What is the color and size of plants grown without light? With light? What is the general effect of no light and white light on the length of the stem? How might you account for this difference?

What is the general effect of the various colors of light on the stem elongation? Compare red and blue light on stem elongation.







Adapted from High School Biology, Green Version - The Laboratory, Part Two, Exercise 12.7, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.
Chester Lawson, and Richard Paulson. Laboratory and Field Studies in Biology (New York: Holt, Rinehart, and Winston, 1960), p. 158.

THE EFFECT OF WATER ON GERMINATION OF SEEDS

PURPOSE

To learn about the best soaking period necessary for seed germination (the effects of too little or too much water).

ACTIVITY MATERIALS

60 seeds (bush beans)
Several small beakers
Graduated cylinder
Seed flat or paper cups
Planting soil or vermiculite or sawdust
Wax marking pencil

WHAT TO DO

Soak 10 seeds in each of the following labeled beakers, adding about 250 ml of water to each beaker: 4 hrs., 24 hrs., 48 hrs., 72 hrs., 96 hrs. Place 10 seeds in beaker labeled 96 hours on first day. Place 10 seeds in beaker labeled 72 hours on second day, and so on. Remove all seeds on Friday and plant them in paper cups or seed flats. Be sure each paper cup is marked with appropriate hours, such as 4 hrs., 24 hrs., 48 hrs., 72 hrs., and 96 hrs. Plant 10 seeds that have not been soaked in a paper cup. Mark this "Control." Add equal amounts of water to each of the containers. Water seeds whenever the surface of the soil appears to be dry. Add equal amounts of water to each container. Observe the containers for each of ten days and record the number of seedlings that have come up in each of the marked containers: 0, 4, 24, 48, 72, and 96. Plot six curves showing the number of young plants that were present each day in each of the six containers. Represent the number of plants on the ordinate and the number of days on the abscissa. Compute the percentage of seeds that were germinated in each group of seeds on the third, seventh, and tenth days.

Is there any advantage to soaking seeds before planting them?

If the experiment were repeated exactly, would you expect to obtain the same results?

Adapted from Chester Lawson, and Richard Paulson. Laboratory and Field Studies in Biology (New York: Holt, Rinehart, and Winston, 1960), p. 227.
Adapted from High School Biology, Green Version - The Laboratory, Part One, Exercise 1.3. BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

UNIT THREE: DISTRIBUTION OF LIFE

EFFECTS OF GRAVITY ON LIVING ORGANISMS

PURPOSE

To learn and understand some of the responses of living organisms to the force of gravity.

ACTIVITY MATERIALS

Several test tubes
Ringstand
Burette clamps
Shoots of Zebrina (Wandering Jew)
Several one-hole rubber stoppers
Corn seeds
Filter paper
Petri dishes

WHAT TO DO

Fill three test tubes with water. Put a leafy shoot of Zebrina through a one-hole rubber stopper and place the rubber stopper into the test tube. Seal the stopper to the test tube with melted paraffin to make it air tight. Follow the same procedure for the other two test tubes. Label each of the three test tubes A, B, and C. Fasten the test tubes to a ringstand with a burrette clamp as shown in diagram in figure 1. Record the responses of the leafy shoots in each tube every day. Do any of the shoots show a negative reaction? A positive reaction? Is there any difference in the response of the shoots because of their different positions?

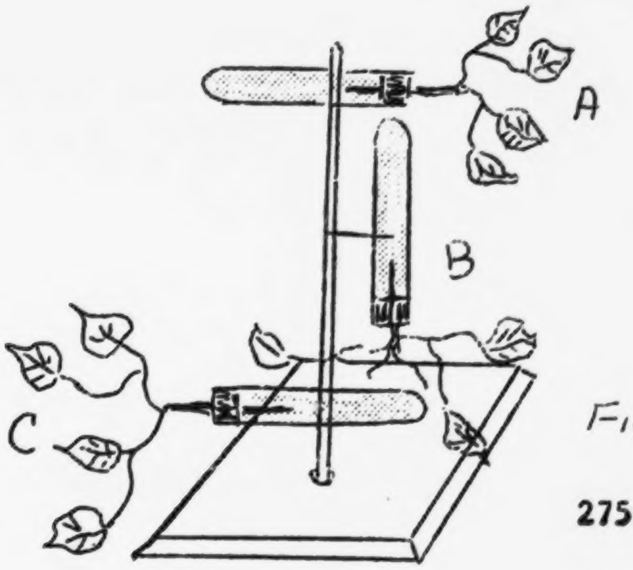


FIGURE 1

Place four soaked corn grains in the bottom of a petri dish as directed in figure 2. Arrange two grains on the horizontal axis with their pointed ends directed toward the center and two grains on the vertical axis with their pointed ends toward the center. Place several soaked pieces of filter paper tightly against the seeds. Cover the dish. Check to see that the grains remain in position when the petri dish is tilted up on its end.

Place the petri dish on its end and attach it to a ringstand with a burette clamp. Mark one grain position with the word "up". Keep it in this vertical position for several days. What direction do the root and shoot grow from each of the grains?

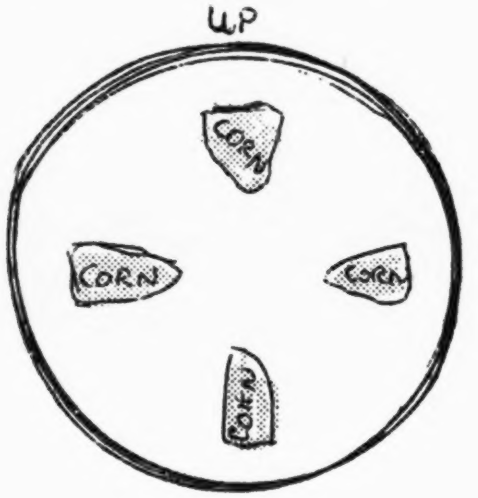


FIGURE 2

Place some radish seedlings on a blotter between two pieces of plate glass. Use string or rubber bands to hold the glass together. Place this set-up into a dish containing water. Observe daily and record what happens for several days. Now reverse the plates so that the edge that was in the water is now on the top. Watch what happens in the next few days. See figure 3

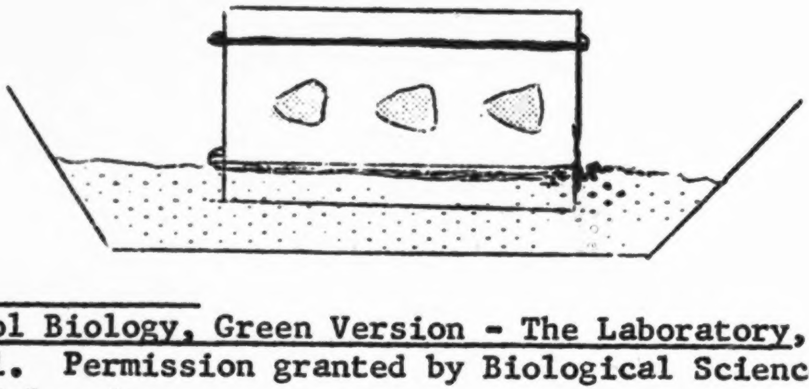


FIGURE 3

High School Biology, Green Version - The Laboratory, Part Two, Exercise 12.7, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

Chester Lawson, and Richard Paulson. Laboratory and Field Studies in Biology (New York: Holt, Rinehart, and Winston, 1960), p. 159.

EFFECTS OF ENVIRONMENT ON TRANSPIRATION RATE IN PLANTS

PURPOSE

To understand that the transpiration rate is due to varying conditions of the environment.

ACTIVITY MATERIALS

Leafy woody branch
Flask
Water (that has been standing at room temperature)
Ring stand
Burette clamp
1-ml pipette
12-cm length of glass tubing bent to a right angle
2-hole stopper
Short length of rubber tubing
Large beaker or battery jar

WHAT TO DO

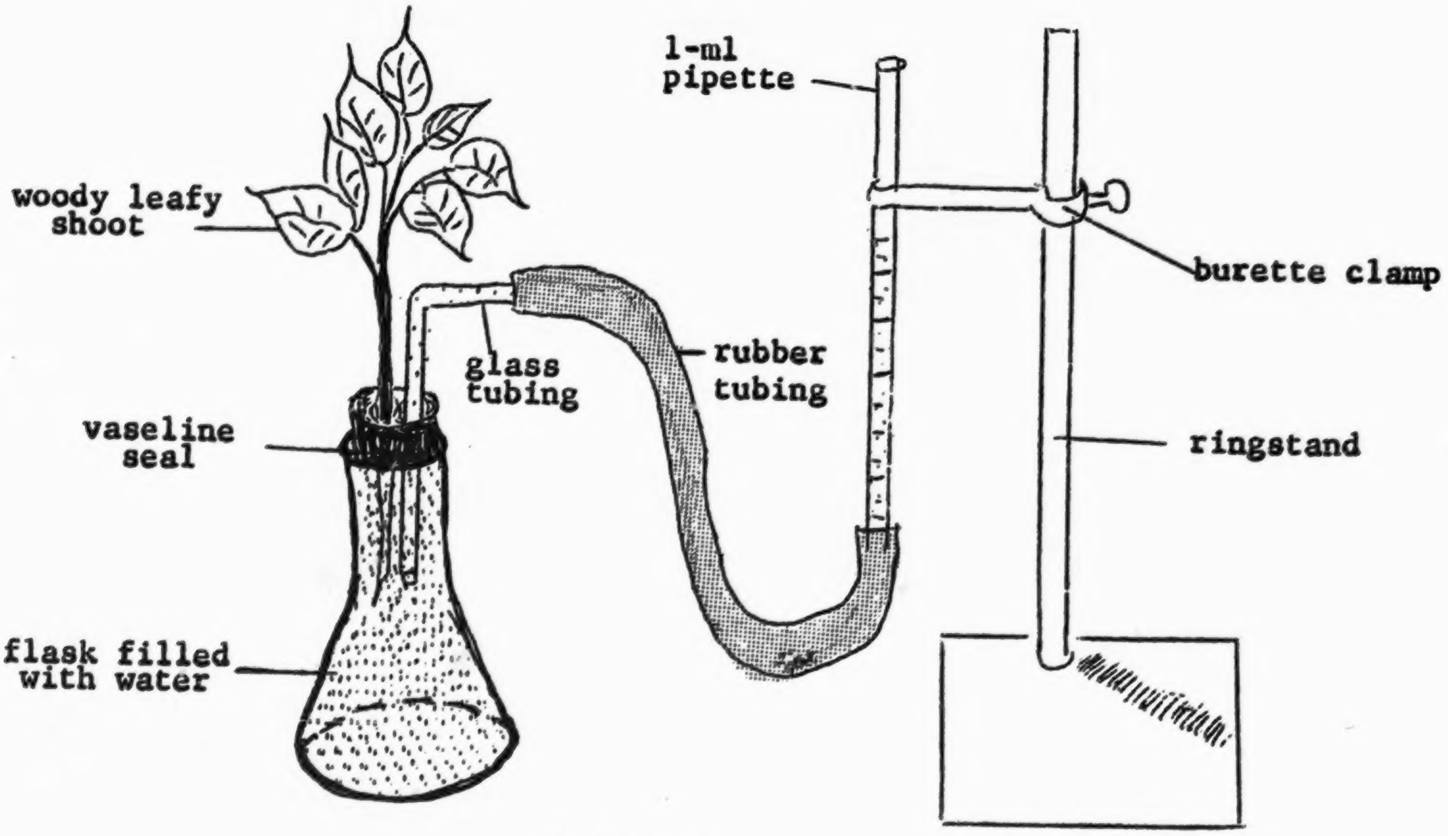
Attach a short length of rubber tubing to one end of a glass tubing bent to a right angle. Insert the opposite end of this glass tubing into a hole of a 2-hole rubber stopper. Cut the stem of a woody, leafy shoot underwater and insert it into the second hole of the 2-hole rubber stopper. Fill a flask to the brim with water. Insert the stopper with the leafy shoot and the glass bent tubing quickly into flask. Some of the water in the flask will overflow, but the force will also cause some of the water to move upward into the glass and rubber tubing. Fill the pipette with water up to the 1-ml mark. Hold the index finger over the top of the pipette until the lower end is inserted in the tubing connected to the flask and a seal is effected. Care must be exercised to eliminate air from the setup. It must be kept airtight. Clamp the pipette to a ring stand for support. (See Figure 1)

Examine markings on the pipette. What volume of water is contained between two adjacent marks? Note the position of the end of the water column. Can you see it move? How will you be able to determine it is moving? In which direction does it move? What causes this motion of the water? Record in a chart the distance the end of the water column moves in a period of two minutes. Do this for a period of 10 minutes.

Begin fanning the air near the leaves. Record water loss at 2-minute intervals for a ten-minute period.

Cover the plant with a plastic bag. Record water loss at 2-minute intervals for a ten-minute period.

Show the results of each experiment on a single graph by plotting each segment with different colored pencils. Plot time on the horizontal axis and the loss of water on vertical axis. What is the variable in this exercise? Account for the slope of the line on your graph? What factors within the plant might affect this rate? What happens to a plant when the transpiration exceeds the rate of absorption?

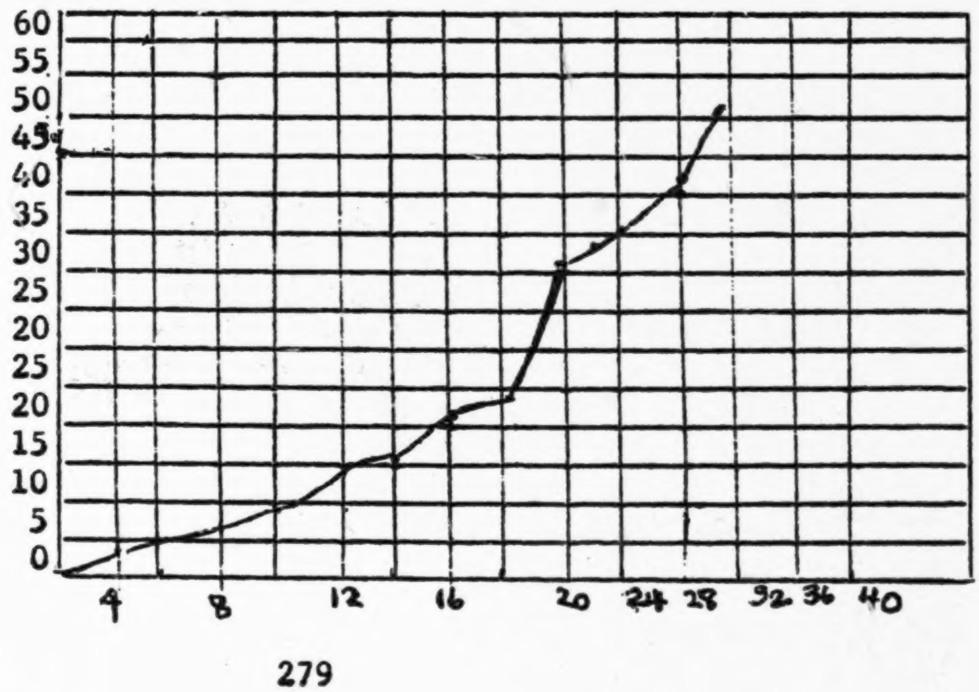

1-ml pipette
woody leafy shoot
burette clamp
glass tubing
rubber tubing
vaseline seal
ringstand
flask filled with water

Potometer
Figure 1

Taken from High School Biology, Green Version - The Laboratory, Part Two, Exercise 12.5, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

Elapsed time	Volume of water lost	
Normal Classroom	Typical class results	
2	1.7	
4	3.1	
6	4.5	
8	6.0	
10	7.4	
With fan		
2	1.5	8.9
4	3.2	12.1
6	4.6	16.7
8	6.2	22.9
10	7.9	30.8
Under plastic bag		
2	1.4	32.2
4	2.7	34.9
6	4.0	38.9
8	5.2	44.1
10	6.8	50.9

A typical class graph



UNIT THREE: DISTRIBUTION OF LIFE

CONCEPTS TO CONSIDER

Saprophytes cannot make their own food, but they do contribute to the growth of other living things.

Parasites live in or on the living bodies of plants or animals and obtain their nourishment from it. Parasites are usually restricted to one or a few species of hosts.

Saprophytes can grow only in places where there are decomposing bodies of animals or plant masses of plant and animal by-products.

Predation is when one species catches, kills, and feeds upon a second species.

Commensalism is a relationship in which one species is benefited and the second species is not affected by existing together.

Mutualism is a relationship in which two species benefit from each other and cannot survive in nature without this relationship.

Protocooperation is a relationship in which both species gain from each other, but are able to survive in nature without this relationship.

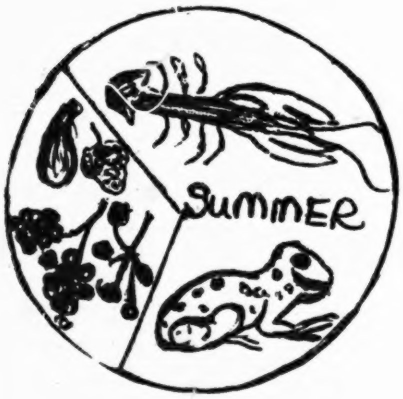
TEACHING APPROACH (Methods and Activities)

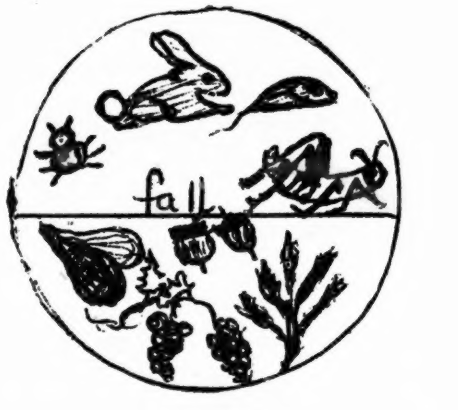
Discuss predation as a characteristic of the biotic environment.

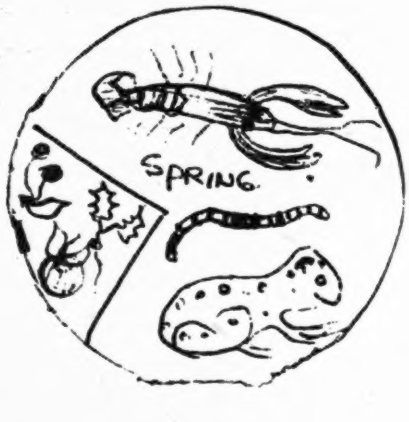
-Students help to prepare a list of predator-prey relationships on the chalk board.

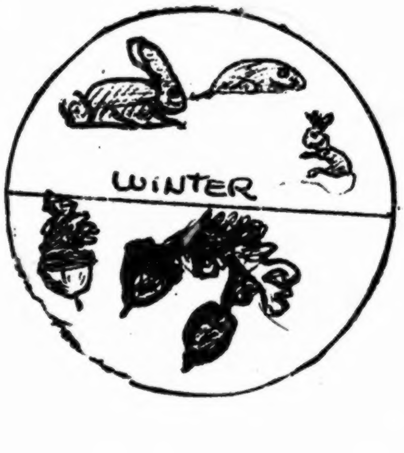
-Discuss the concept that many predator-prey relationships are based on availability of a particular food. Many animals will haye a varied diet during the spring, summer, fall, and winter of the year.

-Diagram the diet of a raccoon, which is a known predator.









-Discuss the adjustments of structure that go with predator habit of food getting.

Discuss differences between carnivores, herbivores, and omnivores

-Display skulls of carnivores, herbivores, and omnivores to show dentition
-Assign students to make a list of the various foods eaten by three groups of animals
-Prepare a list on the chalk board of animals in each of the three groups: carnivores, herbivores, and omnivores
-Discuss specializations of animals to one particular food (monophagy) or to many different types of food (polyphagy)

Discuss filter feeding

-Discuss filter feeding of certain marine animals
-Discuss how availability of food is the major criterion for the distinction of the animal becoming either carnivorous or herbivorous
-Discuss a form of filter-feeding as exhibited by air-breathing animals such as small bats, nighthawks, and swifts---aerial insects
-Discuss how some spiders use their webs as a sieve-feeding device for straining insects

Discuss saprobism such as saprophytes, scavengers, and decomposers

-Students make a bulletin display on various decomposers and how they interact with food webs
-Students help to prepare a list of various decomposers and type of decomposition that takes place and the final substances that are released
-Discuss the difference between decomposer and transformer
-Assign students to make a report on the various scavengers of the seashore, forest, and desert
-Discuss the difference between a scavenger and a saprophyte
-Students make a collection of many kinds of mushrooms. See p. 288 for suggested laboratory activity

Discuss insectivorous plants

-Students may be encouraged to grow insectivorous plants such as sundew, pitcher plant, and Venus fly-trap in a classroom terrarium for special study. See p.289 for suggested activity.

UNIT THREE: DISTRIBUTION OF LIFE

Discuss symbiosis as a characteristic of the biotic environment.

- -Make a list of the three major divisions of symbiotic relationships, such as parasitism, commensalism, and mutualism (protocooperation).
- -Discuss the major characteristics of parasites.
- -Discuss and show through a flannel board demonstration a parasitic food chain.
- -Discuss plant parasites such as molds, yeasts, mushrooms and other types of fungi.
- -Discuss partial plant parasites such as mistletoe.
- -Prepare a display of the various plant parasites.
- -Students prepare a chart showing the location, parasitism, number of hosts and effect.
- -Make a list of the variety of plant parasites found in Southern California.
- -Students bring in plant parasites found in their own backyard (plants parasitizing other plants).
- -Students observe animal parasites. See p. 290.
- -Discuss animal parasites such as mites, ticks, worms, and others.
- -Prepare several flannel board demonstrations to show the life cycle of the liver fluke, tapeworm, and trichina worm.
- -Students prepare a chart showing animal parasites; their location on host; duration of parasitism; necessity; specificity; and others.
- -Discuss major characteristics of commensalism.
- -Prepare a list with students' help of the many relationships of animal-animal commensals or plant-animal commensals or plant-plant commensals.
- -Discuss such commensals, such as glass sponge and its commensals, a pair of shrimp; hermit crab and its commensal annelid, Nereis fucata; Urechis campo, an Echiuroid worm and its commensals (an annelid worm, a crab, and a fish).
- -Discuss commensals of the pitcher plant, whale, shark, and turtles (marine).
- -Discuss commensalism showing only locomotion. Assign students to prepare a list of commensals showing locomotion, support, shelter, and food supply.
- -Discuss and illustrate how some forms of commensalism have evolved into a parasitic relationship.
- -Discuss mutualism in a plant-plant relationship. Students do laboratory activity suggested on page 291.
- -Discuss mutualism in a plant-animal relationship. Students do laboratory activity suggested on page292.
- -Discuss animal-animal relationships showing mutualism. Students do laboratory activity suggested on page 295.

Discuss habitat-niche and interspecific and intraspecific competition.

- Discuss types of habitat-niche.
- Discuss Gause's principle and use suggested laboratory activity on p. 299 to illustrate concept.
- Prepare a list of plants and animals that share similar niches or appear to share similar niches.
- Students do Gause's original experiment to show competition within a niche in simple laboratory populations. See p. 297.
- Briefly discuss territoriality (this will be elaborated in Unit 4).
- Discuss aggregations, societies...especially insect societies.
- Discuss caste differentiations in insect societies.

DEPTH PROBE

- SAPROPHYTES, p. 288 (Average Student Basic Activity)--To understand that some plants receive their food supply from dead organic materials. Students work in groups.

- INSECTIVOROUS PLANTS, p. 289 (More Able Student Basic Activity)--To understand and observe that some plants demonstrate unique food getting methods in addition to photosynthesizing their food. Students work in groups.

- FROGS AND THEIR PARASITES, p. 290 (Average Student Basic Activity)--To learn that certain organisms are very specialized in their food getting adaptations. Students work in groups or individually.

- MUTUALISM IN PLANTS, p. 291 (Average Student Basic Activity)--To learn that certain dissimilar organisms are able to live together in mutual benefit. Students work in groups or individually.

- NITROGEN FIXING BACTERIA, pp. 292-294 (More Able Student Basic Activity)--To understand and learn about the effects of nitrogen-fixing bacteria on leguminous plants. Students work in groups.

- MUTUALISM IN ANIMALS, p. 295 (Average Student Basic Activity)--To understand and learn that certain dissimilar organisms are able to live together in mutual benefit. Students work in pairs or individually.

- COMPETITION WITHIN AN ECOLOGICAL NICHE, p. 297 (More Able Student Basic Activity)--To demonstrate that two species cannot have exactly the same niche even under laboratory conditions. Students work in groups and individually.

- GAUSE'S PRINCIPLE, p. 299 (Average Student Basic Activity)--To understand the concept that no two species can have exactly the same niche. Students work in teams or can be used as a homework assignment.

UNIT THREE: DISTRIBUTION OF LIFE

"TOOLS" FOR EXTENDING CONCEPTS

-Plan to show films:	"Mosquitos and Malaria" Fsd 595.77-1
	"Bacteria: Laboratory Study" Fsd 576-8
	"Spider Engineers" Fsd 595.4-2
	"Food Getting Among Animals" Fsd 591.5-22
	"Plant Traps" Fsd 581.5-4

-Plan to borrow mounts of scale insects from Instructional Materials Center from Catalog of Audio-Visual Materials, Secondary Grades, Pub. 579, 1961 Edition, Los Angeles City Schools, Division of Instructional Services, Audio-Visual Section, p. 144.

-Encourage a student team to make a survey of living organisms found in a one-foot square piece of sod. Students prepare a list of biota of soil and give an oral report of survey to class.

-Assign students to do research on animals showing extreme niche adaptations, as in soldier ants, where the head is used as a door for the nest. Give other examples.

-Encourage a student to do research on the three-year succession of an animal cadaver from vulture and flesh flies to tenebrionid beetles.

-Encourage some students to make a list of animals and plants that have symbiotic relationships showing mutualism. (List should include examples not previously studied in class.)

-Encourage some students to make a list of animals and plants that have symbiotic relationships showing commensals. (List should include examples not previously studied in class.)

-Encourage some students to make a list of animals and plants that have symbiotic relationships showing parasitism. (List should include examples not previously studied in class.)

-Assign students to make a report on seed dispersal as provided for by animals.

-Assign students to make a survey of animals that are "serviced" by birds. Prepare a bulletin board entitled VALET SERVICE.

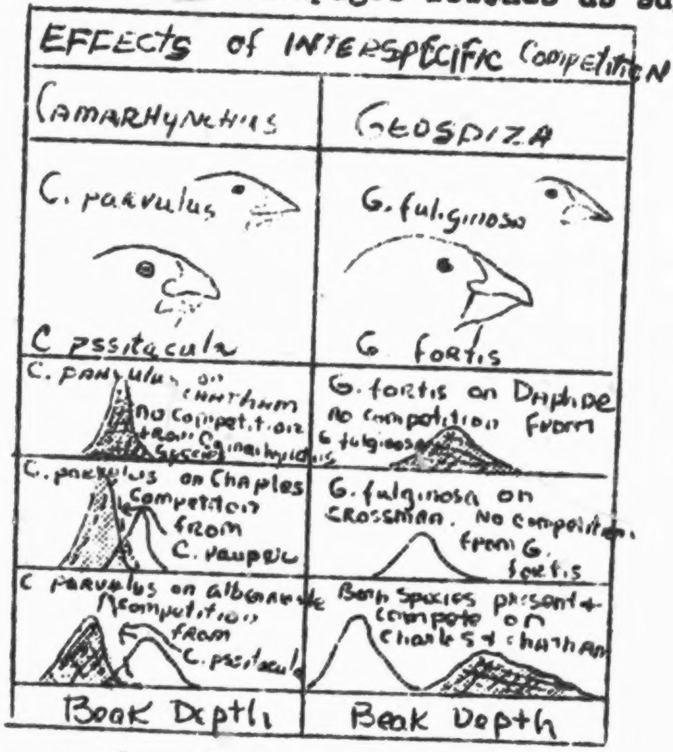
-Students may prepare a report showing parasitism of male animal on female animal in deep sea fish.

-Assign a student to report on "Ant cows" or aphids and how they are put out to "pasture" on plants by ants.

-Assign students to prepare a written report comparing several living organisms showing a similar niche. This should be accompanied with how they are able to live together according to Gause's principle.

-Discuss aggregations of living organisms that come together at night to sleep and then disperse during the daytime, such as bees, wasps, crows, robins, and blackbirds.

- Discuss aggregations of living organisms such as schools of mackerel, herds of buffalo, flocks of gannets and others.
- Encourage some student team to make a survey of living organisms that occupy a similar niche but are geographically separated by large distances, such as American meadow lark and African pipit; Red-winged blackbird and African weaver birds.
- Encourage a student to make a report to the class on odd niches such as pitcher plant, ant-eater, spider that captures food in its purse-like web, and dung beetle.
- Discuss the relationships of saguaro cactus, woodpecker, elf owl, and screech owl.
- Prepare a bulletin board display entitled BIRDS OF A FEATHER FLOCK TOGETHER to illustrate aggregations.
- Discuss animals that live in colonies or societies such as bees, termites, Portuguese man - of - war and others.
- Assign students to report on animals parasitic in man.
- Assign a student group to prepare a bulletin board on geographical distribution of parasitic worms.
- Encourage a student to investigate the enzymes secreted by insectivorous plants and the need for bacterial relationships in these plants.
- Encourage some students to construct a demonstration bee hive and report to the class on insect societies.
- Assign a student to investigate the evolutionary effects of interspecific competition of finches of the Galapagos Islands as suggested in chart given.



Drawn after G. Simpson, et al., Life: An Introduction to Biology (New York: Harcourt, Brace, and World, 1957), p. 629. Permission granted by publishers.

-Start an ant farm for class demonstration and observation.
-Encourage students to prepare three-dimensional models of various members of a termite colony, indicating the caste, type of function, and other interesting facts about the insect society.
-Encourage a student to collect a variety of lichens for classroom display.
-Assign an interested student to report on orchids as a commensal. Survey classes to locate students who grow orchids as a hobby. Ask students to report on the growing orchids to the class.
-Encourage some student to read and report on yucca plant and the relationship of the yucca moth to it.

PLANNING AHEAD

-Locate and store several aquaria to be converted into habitat terraria.
-Store humus, loam, sphagnum moss, and sand.
-Assign students to help collect small reptiles and amphibians such as lizards, salamanders, water turtles and others.
-Order pitcher plant, sundew, and Venus fly-trap for habitat of a bog.
-Ask students to bring in various shapes and sizes of rocks and plants such as cactus, liverworts, small ferns, moss, small vines, and other creeping type dwarf plants.
-Locate and store varieties of corals as a classroom display.
-Review techniques for making a diorama.
-Borrow reprints of the following issues of Life "World We Live In Series": "Land of the Sun" April 5, 1954; "Arctic Barrens" June 7, 1954; "Woods of Home" Nov. 8, 1954; "Rain Forests" Sept. 20, 1954; "Teeming Underwater World of Coral Reefs" Feb. 8, 1954; "Creatures of the Sea" Nov. 30, 1953; "Miracle of the Sea" Feb. 9, 1953.
-Borrow Life Nature Study Series of books from the library, such as Forests, Desert, Mountains, Sea, The Poles, The Earth for use in next section of this unit. Ask students to bring in their own copies of these books for class use.
-Prepare a map of the campus.
-Prepare a list of plants growing on the campus.
-Make arrangements to take classes on a field trip for about 30 minutes of class period on a tour of the campus to study vegetation and animal distribution.
-Encourage students to bring in pictures for bulletin board display. Pictures should include scenes of the desert, mountain, forest, seashore.
-Encourage students to bring their sea shell collections to school.
-Encourage some students to take a field trip to the seashore to study tidepool animals during a low tide.
-Encourage students to make a scrapbook collection of newspaper tide tables of the Southern California area.

UNIT THREE: DISTRIBUTION OF LIFE

- Encourage students to bring in pictures of their own taking of various biome areas to project on a screen for the entire class.
- Locate and reserve several class sets of California Life Zone study maps.
- Locate and reserve several sets of colored pencils or crayolas.
- Review 1961 Catalog of Audio-Visual Materials for Secondary Grades, Pub. 579, Los Angeles City Schools, Division of Instructional Services, Audio-Visual Section. Place order for shore birds; valley birds; birds of the various life zone areas of California. See pp. 140-141 of catalog for suggestions.
- Encourage some students to help start a salt water aquarium.

BROADENING "CONTENT HORIZONS"

Teacher References:

Allee, W. C., et al. Principles of Animal Ecology. Philadelphia: W. B. Saunders Co., 1949.
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Simpson, G., et al. Life: An Introduction to Biology. New York: Harcourt Brace, 1957. (Title III Collection)
Elton, Charles. Animal Ecology. New York: Macmillan, 1927.
Allee, W. C. Social Life of Animals. Boston: Beacon Press, 1958.
Elton, Charles. Ecology of Animals. New York: Wiley Co., 1950.
Clarke, G. L. Elements of Ecology. New York: Wiley Co., 1954.
Woodbury, A. M. General Ecology. Philadelphia: Blakiston, 1954.

Articles from Scientific American
  Schneirla, T. C. and Piel, Gerard. "The Army Ant," (June, 1948)
  Lamb, I. M. "Lichens," (October, 1959)
  Grant, Verne. "The Fertilization of Flowers," (June, 1951)

Student References:

Bonner, John T. Cells and Societies. Princeton, New Jersey: Princeton University Press, 1955.
Pearse, A. S. Introduction to Parasitology. Springfield, Illinois: Charles Thomas, 1942.
Von Frisch, Karl. Bees, Their Vision, Chemical Senses, and Language. Ithaca, New York: Cornell University Press, 1950.
Storer, John. Web of Life. New York: Devin-Adair. Signet Books, 1954.
Von Frisch, Karl. The Dancing Bees, An Account of the Life and Senses of the Honey Bee. New York: Harcourt, Brace, 1955.
Buchsbaum, Ralph and Mildred. Basic Ecology. Pittsburgh, Pa.: Boxwood Press, 1961.

SAPROPHYTES

PURPOSE

To understand that some plants receive their food supply from dead organic materials.

ACTIVITY MATERIALS

Yeast plants
Variety of mushrooms
Molds growing on bread
Molds growing on citrus fruits
Microscope
Slides and cover slips

WHAT TO DO

Observe bread mold and green fruit mold.. Place a small amount of bread mold on a drop of water on a clean slide. Add a cover slip and observe under low and high power. Make sketches of observations. Place a small amount of the green fruit mold on a clean slide in a drop of water. Add a cover slip and observe under low and high power. Make sketches of observations.

How do the plants such as bread mold and green fruit mold get their food? Do these plants manufacture their own food?

Display or make a collection of a variety of mushrooms. Give the method of food getting for each of the mushrooms displayed. What do all of the plants in this exercise have in common? Are they classified in a similar group? If so, in which one are they classified?

INSECTIVOROUS PLANTS

PURPOSE

To understand and observe that some plants demonstrate unique food-getting methods in addition to photosynthesizing their food.

ACTIVITY MATERIALS

Sundew, pitcher plant, Venus fly-trap and others
Utricularia (fresh-water floating plant)
Terrarium
Aquarium

WHAT TO DO

Plant insectivorous plants in a glass-enclosed container (terrarium) to maintain humidity. Prepare soil by mixing together three parts of loam, one part of peat moss, and one part of sand. Water plants occasionally. Feed sundew on fruit flies; Venus fly-trap on mealworms; pitcher plant may survive without insect food.

Add Uticularia to a fresh-water aquarium. Examine the small traps into which microorganisms swim and become captive. Open traps onto a clean slide and observe under low and high power of microscope. Make sketches of observations.

Are these plants able to manufacture their own food by photosynthesis? What explanation can be given to indicate the adaptation for trapping insects?

Reference:
Morholt, Evelyn et al. A Sourcebook for the Biological Sciences. New York: Harcourt, Brace, 1958, pp. 233-34, p.400.

FROGS AND THEIR PARASITES (SYMBIOSIS)

PURPOSE

To learn that certain organisms are very specialized in food-getting adaptations.

ACTIVITY MATERIALS

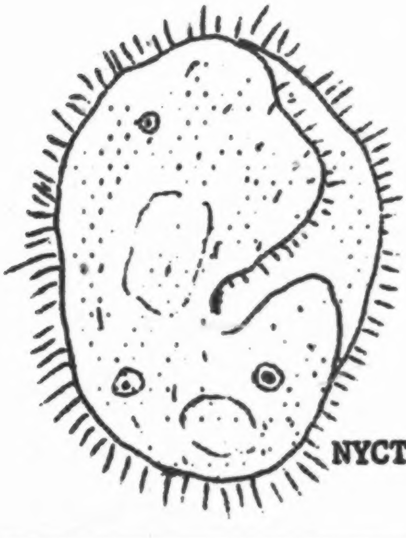
Live frog	Microscope
Dissecting tools	Slides and cover slips
Ringer's solution	

WHAT TO DO

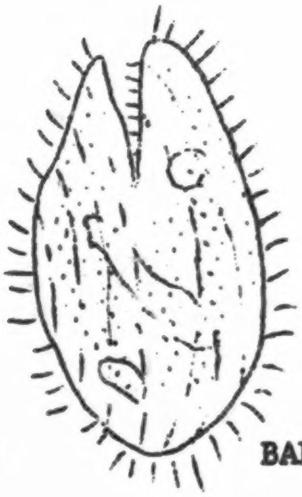
Teacher piths frog for dissection. Student groups dissect frog and observe such organs as lungs and liver for worms. Place worm in a drop of Ringer's solution on a slide and observe under low power of the microscope.

Look for protozoans within the digestive system of the frog. Begin below the stomach and remove a small portion of the upper intestine. Mount the contents of the intestine in a drop of Ringer's solution onto a clean slide. Add the cover slip and observe under low power and then under high power. Make sketches of the various protozoans. Identify protozoan by use of the key. Jahn, T. L. How To Know the Protozoa. Dubuque, Iowa: William C. Brown, 1949.

Cut open the rectum and mount bit of fecal material in 0.7 percent sodium chloride solution. Look for Opalina, a slow-moving ciliate. Sometimes students may discover Nyctotherus and Balantidium.

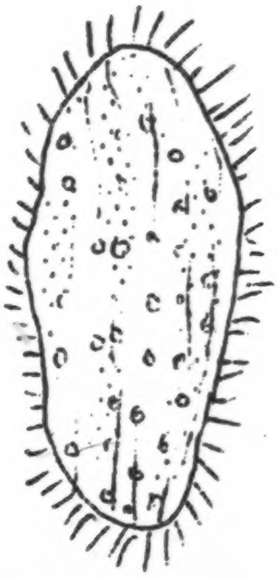


NYCTOTHERUS



BALANTIDIUM

OPALINA



Reference: Morholt, Evelyn, et al. A Sourcebook for the Biological Sciences. New York: Harcourt Brace, 1958, p. 230 and p. 310.

UNIT THREE: DISTRIBUTION OF LIFE

MUTUALISM IN PLANTS (SYMBIOSIS)

PURPOSE

To learn that certain dissimilar organisms are able to live together in mutual benefit.

ACTIVITY MATERIALS

Lichens
Teasing needle
Slide and cover slip
Microscope

WHAT TO DO

Students collect lichens from rocks, moist bricks, and tree barks. Tease a small portion of a lichen from the rock or tree bark and mount on a clean slide in a drop of water. Tease the bit of lichen apart further, add the cover slip and observe under the low power of the microscope. Observe under the high power. Make sketches of both observations. What part of the plant is green? What part of the plant does not have any chlorophyll? Which part is able to photosynthesize its food? Why? How does the other part of the plant get its food? Of what value is each of the organisms to the other? (Figure 1)

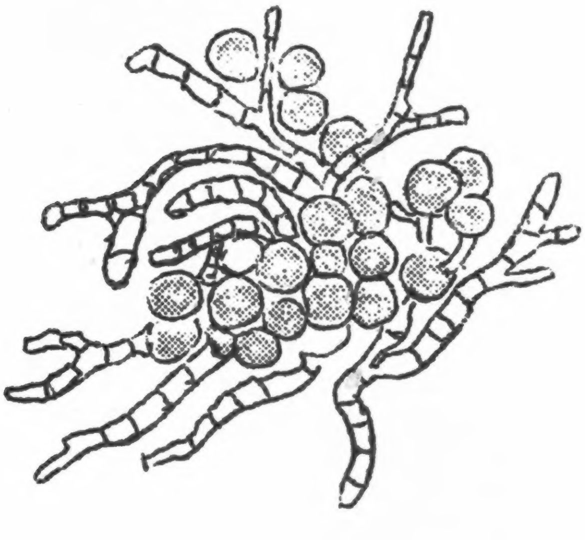


FIGURE 1

NITROGEN-FIXING BACTERIA (SYMBIOSIS)

PURPOSE

To understand and learn about the effects of nitrogen-fixing bacteria on leguminous plants.

ACTIVITY MATERIALS

Commercial Rhizobium inoculum
Clover seed(white or red)
Test tubes (large) or bottles
0.01% sodium hypochlorite solution (Chlorox)
Sterile water (10 ml in test tube)
Alcohol, 70% isopropyl
Crone's solution (see directions below)
Slide and cover slips
Forceps
Pipettes
Mortar and Pestle
Balance scale
Aluminum foil
Cotton plugs

WHAT TO DO

Place 10 ml of water in a test tube and cap with aluminum foil. Fill two other test tubes with Crone's solution. Mix 10.0 grams of Potassium chloride (KCl), 2.5 grams of Calcium Phosphate ($Ca_3(PO_4)_2$), 2.5 grams of magnesium sulfate ($MgSO_4 \cdot 7H_2O$), 2.5 grams of calcium sulfate ($CaSO_4 \cdot 2H_2O$), trace of Iron Phosphate ($FePO_4$) 2.5 grams (K_2HPO_4).

Grind all these salts together and suspend 1.5 grams of the mixture in a liter of distilled water. Add eight grams of agar for each liter for the growth of the plants. Heat the agar, salt, and water to boiling to melt the agar. Stir constantly to prevent burning the agar. Fill two test tubes with about 25-50 ml of medium. Cap each test tube with aluminum foil or plug with cotton. Place all three test tubes (two containing medium and one containing 10 ml of water) in a pressure cooker for sterilization. When agar test tubes are removed they should both be placed at an angle so the surface of the medium will be slanted when it solidifies.

Place 4-6 clover seeds in Chlorox solution for five minutes. This should kill all the bacteria and mold on the seed coat. Sterilize the forceps by dipping it into alcohol and then flaming the tips of the forceps until the alcohol is completely burned away. Remove the seeds from the Chlorox solution with the sterilized forceps and drop them into the test tube of sterile water. Shake the seeds around in the water to rinse them thoroughly.

High School Biology, Green Version - The Laboratory, Part One, Exercise 2.3, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

Resterilize the forceps as described and remove one seed from the water and place it in test tube marked number 1. "Plant" the seed in the middle of the agar slant. Mark this test tube "Control." Label the date, your name, period number, and other remarks. Resterilize the forceps as described and remove a second seed from the water. Sprinkle this seed with the commercial Rhizobium inoculum. Place the inoculated seed in the middle of the agar slant of the test tube marked number 2. Mark this test tube "Test," label date, your name, period, and other remarks.

Set both test tubes in the place indicated for your group. Observe daily, note any changes in the seeds, the seedlings, and finally the plant. Record all your observations.

Watch for the formation of nodules (lumps) on the roots. In three or four weeks measure the stem, the root, and the leaf growth of each plant. Record the differences.

Remove the test plant from the test tube and wash all excess agar from the roots. Look at the roots carefully and note the location of the nodules if any have formed. Now place one of the nodules on a slide to which a drop of water has been added. Crush the nodule with your forceps or with a glass rod. Note the color of the inside of the nodule. Cover the crushed nodule with a cover slip and observe under the microscope. Make sketches of your observations.

What explanation can you make for the apparent differences and similarities of the plants?

ALTERNATE METHOD

Obtain clover plants from nearby fields. Dig up the entire plant with a few inches of the soil surrounding the roots. Wash the soil off in water. Remove a nodule from the roots of this plant and place it on a drop of water on a slide. Place another slide over this and crush the nodule with a circular motion. You now have two slides with a little of the crushed nodule on each. Use both slides. Fix each slide smear with heat and then cover each smear with a dilute carbol-fuchsin stain. After three to four minutes wash both slides carefully in a rinsing jar. Dry most of the slide and then cover with a cover slip. Examine under low and high power. Draw as many different forms as you see.

Dilute carbol-fuchsin stain:
5% aqueous solution of phenol 90cc
Basic carbol-fuchsin saturated in 95% alcoholic solution 10cc
Dilute this stock solution in 10 parts water.

1 gm of basic fuchsin 10 cc of absolute alcohol	MIX WITH	5 gm of phenol 100 cc of distilled water

Dilute this solution in 10 parts water.*

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*Reference: Morholt, et al. A Sourcebook for the Biological Sciences. New York: Harcourt, Brace, 1958, p. 329.

MUTUALISM IN ANIMALS (SYMBIOSIS)

PURPOSE

To understand and learn that certain dissimilar organisms are able to live together in mutual benefit.

ACTIVITY MATERIALS

Live termites (if available)
Green Hydra (order from Science Center)
Green Paramecia (order from Science Center)

WHAT TO DO

Place a termite in a drop of Ringer's solution on a clean slide. Use a forceps to hold down the abdomen on the slide. With another forceps pull off its head. The intestine will be found attached to the head part. Remove the remains of the termite from the slide, keeping only the intestine. Macerate the intestinal contents, and then add a cover slip. Observe under low power and then under high power. Observe sections of the intestine to locate protozoans attached or moving about. See Figure 1.

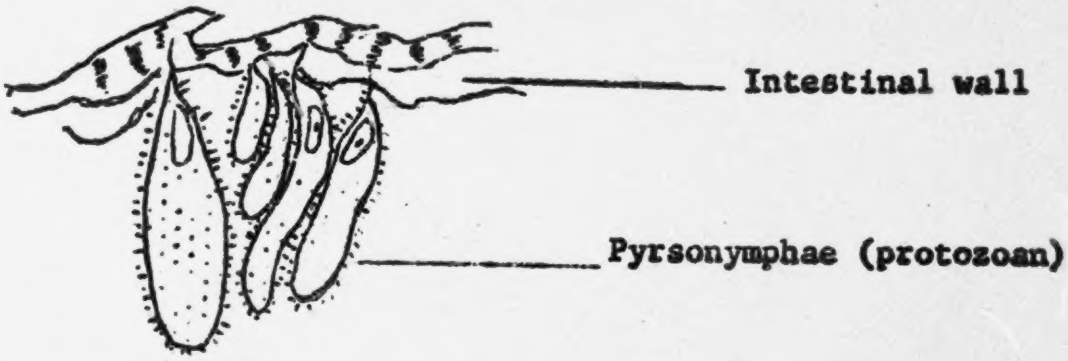


FIGURE 1*

What purpose do the protozoans serve in the intestine of the termite? What function does the termite serve for the protozoans? Can a termite live without the protozoan?

Reference: Morholt, Evelyn et al. A Sourcebook for the Biological Sciences. New York: Harcourt, Brace, 1958, p. 311.

*Figure 1. Drawn after, Ibid p. 311.

UNIT THREE: DISTRIBUTION OF LIFE

Carefully remove a green hydra and mount it in a drop of water on a clean slide. Observe under the low power of the microscope. Make a sketch of the entire animal. Observe its movements. Macerate the hydra with teasing needles to release the green zoochlorellae. Observe these minute organisms under high power of the microscope.

What purpose do these zoochlorellae serve? Is the hydra able to live successfully without them? Are these minute cells plants or animals?

Mount green protozoa in a drop of pond water on a clean slide. Add a cover slip and observe under low power and high power of the microscope. Make sketches of the green paramecia. What are the green particles? Of what value are they to the Paramecium? Are the green cells plants or animals?

Reference: Morholt, Evelyn et al. A Sourcebook for the Biological Science. New York: Harcourt, Brace, p. 233 and p. 312.

COMPETITION WITHIN AN ECOLOGICAL NICHE

PURPOSE

To demonstrate that two species cannot have exactly the same niche even under laboratory conditions.

ACTIVITY MATERIALS

Cultures of Paramecium caudatum, Paramecium bursaria, and Paramecium aurelia.
Culture of Daphnia pulicaria, Daphnia magna, and Simocephalus.
Culture of yeast and algae.

WHAT TO DO

Prepare two separate cultures of Paramecium caudatum and Paramecium aurelia. Each type of ciliate may be grown in a mixed culture. Make a population count of each type of ciliate and plot a curve of growth on a graph.

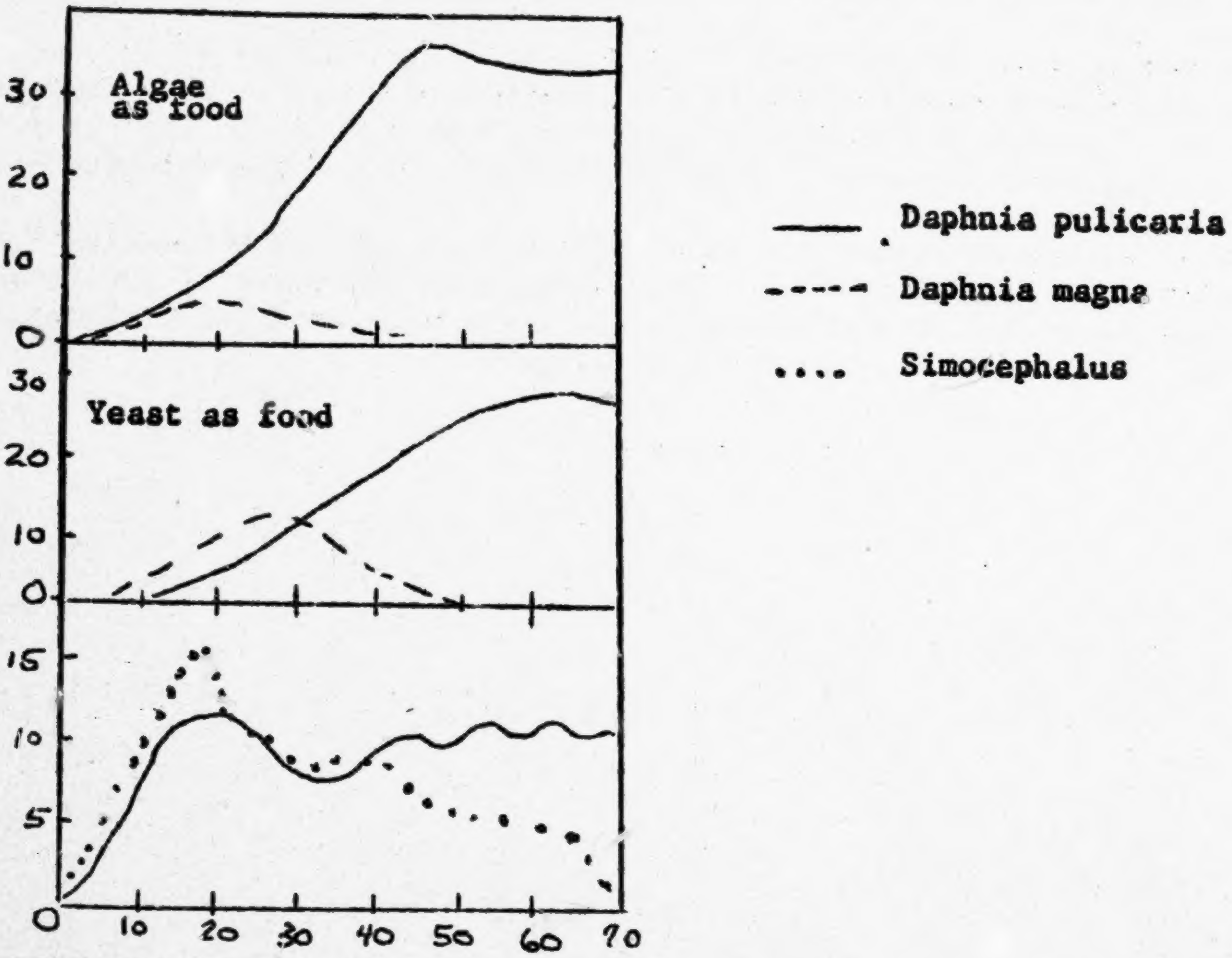
Now mix the culture of Paramecium caudatum with the culture of Paramecium aurelia and make population counts for about sixteen days. What happens to the curve of growth of Paramecium caudatum? What happens to the curve of growth of Paramecium aurelia? Give valid reasons for these two growth curves.

Prepare a culture of Paramecium caudatum and a culture of Paramecium bursaria. Follow procedure as given above. What happens to the curve of growth for Paramecium caudatum? What happens to the curve of growth for Paramecium bursaria? Give valid reasons for your answers.

Prepare separate cultures of Daphnia magna, Daphnia pulicaria, and Simocephalus.

Mix two cultures of Daphnia magna and Daphnia pulicaria together in a culture tube that contains yeast as food and a culture tube that contains algae as food. Make population counts of each culture tube and show the relationship of these two water flea populations in competition for food. Plot a curve of growth on a graph for two species of Daphnia growing in yeast and the same for the Daphnia growing in an algae culture. Make observations for about twenty-five days. Which species persisted under the yeast culture? Which species persisted under the algae culture? Is there any appreciable difference between these two studies? If so, what are the differences?

Prepare a culture of Simocephalus and Daphnia pulicaria. Plot a curve of growth for these organisms in a mixed culture for twenty days. How does the curve differ from the population study shown between Daphnia pulicaria and Daphnia magna? Do these two organisms occupy the same niche? Do they occupy separate niches? Do their niches overlap?



Charts drawn after E. Odum, et al., Fundamentals of Ecology (Philadelphia, Pa.: Saunders, 1959), p. 232. By permission of publishers.

GAUSE'S PRINCIPLE

PURPOSE

To better understand the concept that no two species can have exactly the same niche.

ACTIVITY MATERIALS

Cutouts of five types of American Warbler

Dendroica virens (Black-throated green warbler)	D.v.
Dendroica fusca (Blackburnian warbler)	D.f.
Dendroica tigrina (Cape May warbler)	D.t.
Dendroica castanea (Bay-breasted warbler)	D. ca.
Dendroica coronata (Myrtle warbler)	D. co.

Cutouts of design shown in Figure 1.

WHAT TO DO

Give an explanation of the zonation of these five species of warbler.

Students may report on the habits of each species and then try to correlate the various niches for that particular species.

A-Outermost zone of new needles and buds.
B-A middle zone of old needles
C-Inner zone of bare or lichen-covered branches.

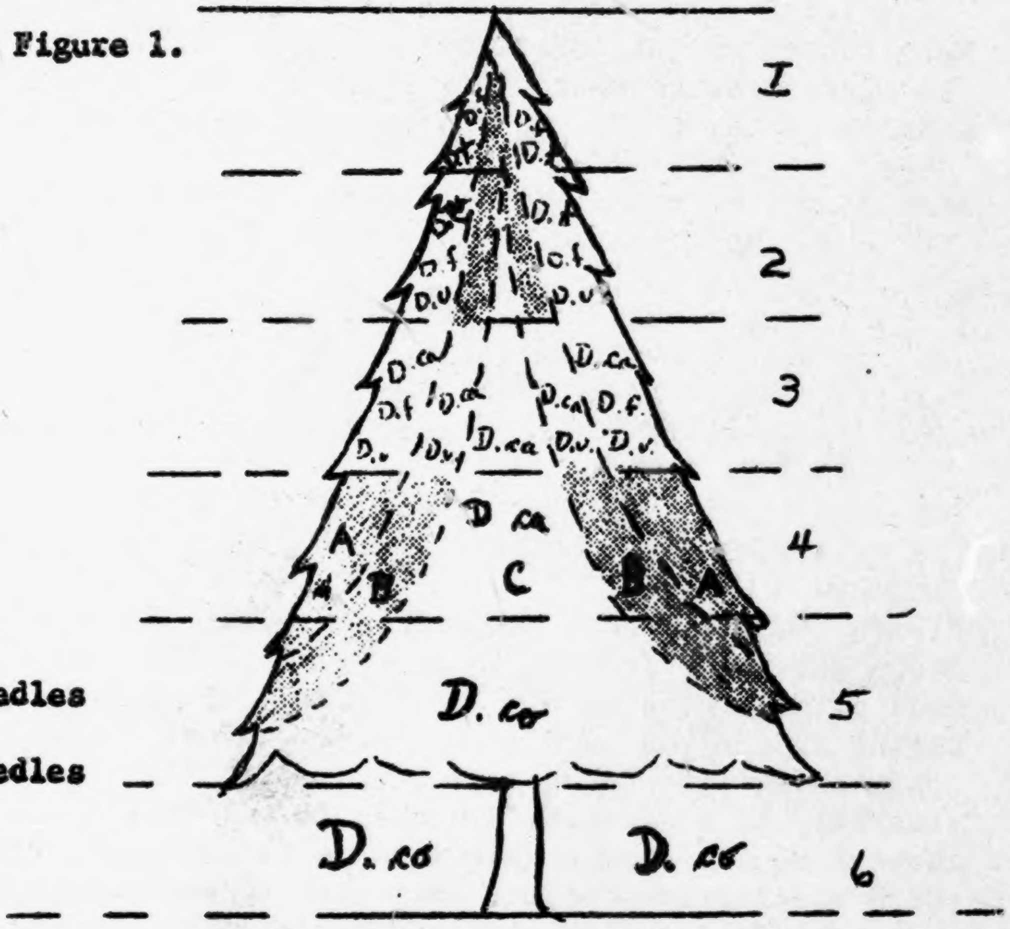


FIGURE 1

Redrawn from Earl Hanson, Animal Diversity (Englewood Cliffs, N. J.: Prentice-Hall, 1961), p. 62. By permission of Prentice-Hall, Inc., publishers.

UNIT THREE: DISTRIBUTION OF LIFE

CONCEPTS TO CONSIDER

Biome is a landscape type and its characteristic assemblage of living organisms.

Biomes gradually grade into each other and do not have precise boundaries.

Living things are distributed to particular regions about the world, depending on the tolerance of these organisms to the varying environmental factors of the earth's surface.

Soil, temperature, and rainfall play a vital role as geographic latitude and altitude vary. These factors tend to divide the soil-surfaced earth into a number of distinct habitat zones, such as desert, grassland, rain forest, deciduous forest, taiga, and tundra.

Tundra is a biome that has a very short growing season, low precipitation, and a sub-soil which remains frozen throughout the year. The summer period is short with drying winds resulting in high evaporation.

Plants of the tundra are low growing, small of size, with hairy covering, often very large flowers appear in relation to the entire plant.

Many tundra animals dig under the snow for protection; or snow may lead them to migrate south, where more abundant food is to be found.

Animals of the tundra have basic adaptations for movement in snow; stilt-like legs, or oversized feet.

Animals of the tundra sometimes show marked change in plumage or fur color; white in the winter and sand or brown in the summer.

Characteristic animal and plant of the taiga is the spruce-moose community.

Taiga is just south of the tundra and is characterized by longer growing seasons and greater summer warmth, which permits larger plants to establish and grow.

Temperature decreases with elevation. Decrease of three degrees F every 1000 feet is equivalent to the same decrease in advance of three degrees latitude northward.

The velocity of wind increases with elevation.

The rainfall on mountains is usually high on the windward side and low on the leeward side.

Plants generally grow in greater numbers on the windward side of mountains.

Trees generally grow up to an elevation known as the tree line.

Most animals live on the lower slopes of the windward side of the mountain.

Living conditions grow more severe as both latitude and altitude increases, and only those life forms especially adapted to low temperature, rocky terrain, and scarcity of vegetation are able to survive.

Above tree line the temperature is so low that vegetation is small and scattered with special adaptations for water retention and severe cold.

Heavy rainfall and an almost constant high temperature all through the year give rise to the richest vegetation and the most numerous animals.

Animals of the rain forest live in the tree tops, where food is more plentiful.

UNIT THREE: DISTRIBUTION OF LIFE

Forest trees serve as support for many kinds of great woody vines.

Rain forests have three general layers of plant and animal life; the upper canopy, middle canopy, and the lower canopy.

Grasslands that border rain forests have alternating dry (drought) periods and rainy seasons.

Grasslands support great numbers of animals.

Factors which most affect living things in fresh-water lakes and ponds are temperature, oxygen, sunlight, movement of water, and impurities.

Most plants that grow in fresh-water extend their leaves above the surface of the water.

Changes in insect populations in small streams will greatly affect the numbers of stream fish.

There is a complete absence of plankton in a headwaters stream system.

Inland water environments are basically divided into standing waters and flowing waters.

Inland water ecosystems are based on special conditions of the environment.

Freshwater habitats change more rapidly than other biomes; ponds become swamps; swamps become filled in and converted to dry land; streams erode their banks and change their course. The kinds of plants and animals may change markedly and show ecologic successions similar to those on land.

Deserts are marked by low precipitation, generally ten inches per year or less, which may fall during a few heavy cloud bursts at erratic intervals.

Deserts are characterized by intense solar radiation during summer and high evaporation rate.

Extremes of day and night temperatures are characteristic of deserts; high day temperature and low night temperature.

Desert plants are small; some have tremendously long roots; some are able to store water in spongy tissue; some may have little or no leaves to help reduce transpiration rate, while others may have a very short growing season.

Desert animals are adapted to desert life in that almost all are burrowing, nocturnal feeders, and small and light in color.

Many desert animals are able to live without water because they are able to produce "water of metabolism" from the dry seeds eaten as food.

About seventy percent of the earth's surface is covered by oceans.

The average depth of the sea is much greater than the average height of the land.

Average sea water contains 3.5 percent of dissolved salts.

At great depths in the sea, temperature differences almost entirely disappear.

Marine life is classified into two large groups, benthic and pelagic; those organisms that are associated with the bottom and those that swim or float near the surface of the water.

Pressure increases with depth.

Factors of light, temperature, salinity, and pressure determine for the most part the zones where animals live in the sea.

UNIT THREE: DISTRIBUTION OF LIFE

Most forms of life are found near the surface.

Those living organisms that are found at greater depths have made special adaptions for deep-sea living, such as smaller bodies, large eyes, dark red or black color, bioluminescence, large mouth, and large teeth.

Plants may be found anywhere from the surface to a depth of about two hundred feet.

Like the land, the ocean consists of regions characterized by different physical conditions and consequently inhabited by specific kinds of plants and animals. This zonation is vertical rather than horizontal.

Plankton are floating organisms, while nekton are swimming organisms, both groups making up a broad grouping called the pelagic zone.

Only bony or luminous animal forms are able to survive in the deep-sea zone.

The maximum and minimum tolerances of an organism limit the kinds of environments in which it can survive.

Major climatic regions result from the uneven distribution of radiant energy from the sun and the consequent movements of masses of air.

Each species in an established community has a distinctly different niche.

Animals are usually darker in the upper parts, where they receive the most light, and lighter in the under parts, where they receive the most shadows. This shading causes them to blend with their background.

Plants and animal populations are controlled by environmental limitations. This condition helps to prevent certain species from over-populating all parts of the world.

The habitat of an organism is the place where it lives, a physical area, some specific part of the earth's surface, air, soil, or water.

An ecologic niche is the range of movement of an organism, what the organism eats, its effects on other organisms, and its effects on the non-living parts of its surroundings.

Animals with distinct life stages occupy in succession different niches.

No two forms can share an ecological niche for an indefinite period of time; eventually one form will replace the other.

Within any one species, average size of individuals tends to be smaller in warmer climates and larger in colder climates.

Within any one species, protruding parts such as tails, ears, or bills tend to be shorter in colder climates than in warmer climates.

Within any one species, colors tend to be darker in warm, moist climates, and lighter in cold dry climates.

Each species of plant or animal originated only once. The particular place where this occurred is known as its center of origin.

In general, closely related species do not have identical ranges; nor are their ranges far apart; they are usually adjacent, but separated by a barrier of some sort, such as a mountain or a desert. (Jordan's rule.)

TEACHING APPROACH (Methods and Activities)

Discuss the life zone concept.

- -Students prepare a plan of the school campus as directed by teacher.
- -Prepare lists of plants growing on school campus. Ditto lists and pass out to students.
- -Take students on a field trip of the school campus during the class period. Select a route that will illustrate principles of distribution. Students should record the plants seen and mark them on their campus map. Try to record the temperature at various locations; record the sunlight intensity and whether the plants are growing in shade, bright sunlight, or filtered sunlight, and any other factors that may be easily observed.
- -After the field trip is over prepare a display of the plants and animals growing on the school campus for closer observation by students.
- -Students help to prepare an urban exhibit of plants and animals characteristic of Los Angeles City. Suggested animals may be gopher, garden snake, alligator lizard, Brown towhee, Brewer's Blackbird, English Sparrow, Swallowtail butterfly, grasshopper, frogs, and so on.
- -Students prepare a map of Los Angeles County to show rivers, lakes, mountains, hills, deserts, reservoirs, national parks, seashore areas, and so on.
- -Students prepare a profile of a fictitious trip through Los Angeles County.
- -Students are given road maps to help with the profile of the county.
- -Select several points on the map that will take the student from the seashore through the Los Angeles basin, over the Hollywood Hills, down into the valley, and over the San Gabriel mountains into the Mojave desert. From these selected points the student must find the elevation, the distance between points, and then plot this on a graph to form the profile. This activity should be done in scale.
- -Discuss the life zone concept as exhibited in California.
- -Students color in the life zones of California, using definite code colors for the life zone described.
- -Students may make a profile of the life zone areas by a cut through the state showing the seashore, coastal range, great valley, Sierra Nevada, and desert.
- -Students color in the profile according to the code colors established in the life zone map of California.
- -Prepare a display of pictures characteristic of the life zones in California and place them on the bulletin board.

Discuss some famous generalizations of plant and animal distribution.

-Assign students to bring in pictures or make drawings of a variety of animals to illustrate Bergmann's rule, Gloger's rule, and Allen's rule. See p. 315. for suggested activities.
-Assign students to make a list of barriers to dispersion. See suggested activity of p. 316.
-Assign a student team to report on the effects of altitude and latitude on the distribution of living organisms.
-Students prepare a large map of the world for bulletin board use. Assign various members of the team to illustrate animals that exhibit Allen's, Gloger's, and Bergmann's rules.
-Assign some students to make a list of animals that do not follow these generalizations.
-Discuss Abert and Kaibab squirrels to illustrate how the Grand Canyon is a barrier. Assign students to look for pictures of these two squirrels and bring them in for a bulletin board display.
-Assign a student to report about the Grand Canyon area and to find other examples of how living organisms are different on the two sides of the canyon rim.
-Assign a student to report on "filter bridges" and "sweepstakes route" for distribution of living organisms.
-Review information about the Island of Krakatau in understanding of the "sweepstakes route" of distribution.
-Assign a student to report on the distribution of animals and plants to the Hawaiian Islands. Ask the student to discuss barriers to distribution.

Discuss Biomes

-Assign several student teams to help in the construction of a variety of habitat terraria. See pp. 322-323. for suggestions.
-Students may wish to select a particular biome for a group project. Assign students to report on and build three-dimensional dioramas of the various biomes.
-Discuss forests and mountains of the world. Students prepare a study world map chart with the forest regions of the world. Discuss the effect of rainfall patterns on the distribution of forest regions. See pp.324-325.
-Discuss deserts (especially of Southern California) of the world. Students prepare a study map of the world showing the known major desert regions. Discuss what makes a desert.
-Assign students to prepare a bulletin board display entitled LAND IN THE SUN. Students make a display of plants and animals found on the desert.
-Assign the class to prepare a map showing the desert regions of California. Discuss the rainfall patterns of these regions.

- -Discuss aestivation and "water of metabolism" as survival factors for many desert animals.
- -Discuss freshwater ponds and review material on food chains in freshwater lakes and ponds. Discuss the difference between living organisms in swift moving streams and those that live in a pond or lake.
- -Discuss the grassland. Show pictures of grassland plants and animals. List the rainfall patterns and temperatures.
- -Discuss seashore biome. Assign students to make a collection of the various seashore animals.
- -Assign one student to report on tidepool habitat.
- -Prepare ditto copies of the seashore profile, as suggested on p. 327. Students use the profile by listing the characteristics of each of the levels of the profile. Student groups are assigned to make a study of living organisms at each level of the profile and to report to the entire class.
- -One student from each team should be encouraged to contribute large cutouts of the team's research for a bulletin board display showing the SEASHORE PROFILE.
- -Discuss zonation on a rocky shore, as suggested on pp. 329- 330.
- -Discuss oceans of the world.
- -Students prepare a study map of the world showing the ocean currents, drifts, and others.
- -Display the profile of the oceans as suggested on p. 328.
- -Assign students questions to be answered as a homework assignment, as suggested on pp. 329-330.
- -Assign student teams to prepare a large map of ocean geography. A suggested reference for this is Engel, Leonard The Sea, Time, Inc. 1961. pp. 63-67.
- -Make a display of corals. Students make a study of coral growths the world over. See pp. 333-334 for suggested activity.

Discuss biogeographic realms of the world.

- -Assign student teams to make an investigation of the various realms and to report to the class about the living organisms characteristic of their particular realm.
- -Students make cutouts of various animals characteristic of their biogeographic realm and place these cutouts on large outlines of the world for a bulletin board display.
- -Students prepare a world map showing the various biogeographic realms (after Wallace).

UNIT THREE: DISTRIBUTION OF LIFE

DEPTH PROBE

- **ALLEN'S RULE, p. 315** (Average Student Basic Activity)--To understand the concept that within any one species, protruding parts such as tails, ears, or bills tend to be shorter in colder than warmer climates. Students work individually.
- **BERGMANN'S AND GLOGER'S RULES, p. 316** (Average Student Basic Activity)--To understand that within any one species, the average size of individuals tends to be smaller in warmer climates and larger in colder climates (Bergmann's rule) and that the colors tend to be darker in warm, moist climates and lighter in cold, dry climates (Gloger's rule). Students work individually.
- **BARRIERS TO DISPERSION, pp. 317-318** (Average Student Basic Activity)--To learn and understand how geographic barriers may prevent dispersion of living organisms. Students work in pairs or individually.
- **EFFECTS OF ALTITUDE AND LATITUDE, pp. 319-321** (Average Student Basic Activity)--To understand and learn that latitude and altitude are limiting factors in the distribution of living organisms. Students work individually.
- **CONSTRUCTION OF HABITATS, pp. 322-323** (More Able Student Basic Activity)--(Average Student Basic Activity)--To illustrate the principles of distribution by creating a specific habitat in the classroom laboratory. Students work in groups.
- **FORESTS, p. 324** (Average Student Basic Activity)--To learn the geographical location of the major forests of the world and their distribution patterns. Students work individually.
- **STRATIFICATION IN FORESTS, p. 325** (Average Student Basic Activity--Optional)--To learn and understand the concept of stratification as it occurs in forests and how this affects the distribution of living organisms. Students work individually.
- **DESERTS: HOW THEY ARE FORMED AND WHERE THEY ARE LOCATED, p. 326** (Average Student Basic Activity)--To learn and understand how deserts are formed and their geographical locations around the world. Students work individually.
- **SEASHORE PROFILE, p. 327** (Average Student Basic Activity)--To illustrate the principle of distribution at the seashore through a seashore profile. Students work individually or in groups.

- ZONATION OF A ROCKY SHORE, pp. 329-330 (More Able Student Basic Activity--Optional)--To understand that the difference of a steeply sloping rocky shore may be compared to that of habitats that are thousands of feet apart in the climatic zones of mountains. Students work individually or in groups.
- OCEANS: THEIR LOCATIONS AND GEOGRAPHY, pp. 331-332 (Average Student Basic Activity)--To illustrate the geography of oceans of the world and to show by the use of a profile the important geographical locations. Students work individually.
- CORAL GROWTHS, pp. 333-334 (More Able Student Basic Activity)--To learn and understand how the temperature of the water, the ocean currents, and other factors determine the distribution of coral growths. Students work individually.

"TOOLS" FOR EXTENDING CONCEPTS

- Plan to show films:
  "Adelie Penquins of the Antarctic" Fsd 598.2-20
  "Australia's Coral Wonderland" Fsd 591.92-10
  "Beaver Valley" Fsd 599.32-1
  "Blind as a Bat" Fsd 599.4-1
  "The Changing Forest" Fsd 634.9-48
  "Life in the Sea" Fsd 591.92-93
  "The Prairie" Fsd 551.58-3
  "Water Birds" Fsd 598.2-21
  "The Spruce Bog" Fsd 634.97-1
  "Life in a Pond" Fsd 591.92-9
  "Parade of Life" Fsd 574.5-3
  "Slow as a Sloth" Fsd 574.5-2
  "The Desert" Fsd 979.4-4 (Jr. H.)
  "Sounds in the Sea" Fsd 597-4
- Plan to show filmstrips:
  "Plant and Animal Environment" S-90 Set 1
  "The Arctic Wilderness" S-138 Set 1
  "Creatures of the Sea" S-131 Set 1
  "Arctic Tundra" S-134 Set 1
  "The African Lion" S-117 Set 1
  "The Living Desert" S-107 Set 1 through 6
  "The Vanishing Prairie" S-118 Set 1
  "The Miracle of the Sea" S-126 Set 1
  "Coral Reef" S-132 Set 1
  "The Desert" S-133 Set 1
  "The Woods of Home" S-136 Set 1
  "The Rain Forest" S-135 Set 1

UNIT THREE: DISTRIBUTION OF LIFE

-Borrow 2" X 2" slides: "California Birds" Sets 10, 11 and 12 S-2
"Chaparral" Set 1 A-3
"Foothill Woodland" Set 1 A-2
"Valley Grassland" Set 1 A-1
"Snakes of Southern California" Set 1 S-5
"California Wildflowers" Set 1 S-1

-Borrow Transcription No. 510C "John James Audubon"
-Borrow exhibits of birds, marine life, insects and others, pp. 139-145. Catalog of Audio-Visual Materials, Secondary Grades. Los Angeles City Schools. Division of Instructional Services, Audio-Visual Section. Publication 579: 1961.
-Locate and borrow books from the library, Life Nature Series: Farb, Peter. The Forest. Time Inc., New York: 1961; Milne, Lorus and Margery. The Mountains, Time Inc., New York: 1962; Engel, Leonard The Sea. Time Inc., New York: 1961; Leopold, A. Starker. The Desert. Time, Inc., New York: 1961; Ley, Willy. The Poles, Time, Inc. New York: 1962; Beiser, Arthur. The Earth, Time, Inc., New York: 1962.

-Encourage a student team to make a study of the arctic and antarctic regions.
-Prepare maps of the two regions, arctic and antarctic, showing the variety of animals and plants as distributed in each zone.
-Encourage students to give reports on animals of the desert.
-Discuss the variations in tides around the world.
-Discuss how beaches are made and how shorelines vary.
-Plan a field trip to the beach during low tide. (Outline Course of Study)
-Encourage students to keep a record of low and high tide marks. Gather data from daily newspapers.
-Assign some students to start a salt water aquarium for classroom observation.
-Encourage students to read about new methods for getting food from the sea.
-Send for or borrow reprints from Life, "The World We Live In" (see p. 286).
-Encourage students to read Carson, Rachel. The Sea Around Us. Mentor Books, New York: 1954 and The Edge of the Sea, Mentor Books, New York: 1955.
-Encourage students to read Bates, Marston. The Forest and the Sea, Mentor Books. New York: 1960
-Assign students to prepare a bulletin board entitled BEACH AND SEA ANIMALS.
-Encourage a student to make a report on the adventures of Auguste Piccard and his son during their research in the Bathyscaph.
-Discuss the importance of the I.G.Y.
-Encourage students to report on the use of sonar in mapping the ocean floor.
-Assign a student to report on the camel's ability to go without water for long periods of time.
-Prepare a bulletin board entitled LAND FORMS OF THE DESERT. Assign students to help in making a study of the various land forms found throughout deserts of the world.

UNIT THREE: DISTRIBUTION OF LIFE

-Encourage students to read about the Emperor Penguin and its way of life.
-Assign a student team to report on the formation of coral reefs and coral islands.
-Assign a student team to make a report of tundra life-- its plants and animals and the characteristics of a tundra-type biome.
-Assign a student to report on the living organisms of the deep sea and their use of bioluminescence.
-Discuss the "red tide"; discuss the use of fossil foraminifera as an indicator in petroleum geology.
-Encourage a student team to make a report on tropical rain forests---their plants and animals.
-Discuss the stratification concept and compare two stratified areas such as the Tropical Rain Forest and the Coniferous Forest. Discuss the plant and animal stratification of each forest biome (see p. 325).
-Discuss the chaparral biome. Assign several students to make a report on the plants and animals of this biome.
-Discuss the wave action far out at sea and near the shore.
-Encourage several students to make a collection of marine algae.
-Prepare a ditto sheet giving general depths and heights of oceans and land masses, such as diagram shown on page 310 (figure 1.)
-Discuss the plants that grow on the sand dunes of the beaches. Assign students to bring in pictures of these plants and prepare a bulletin board display.
-Discuss root systems of plants of the desert. Make comparisons of a variety of plants and their adaptations to this biome.
-Assign students to make cutouts of birds of the various biomes and place them on a bulletin board for display and study.

UNIT THREE: DISTRIBUTION OF LIFE

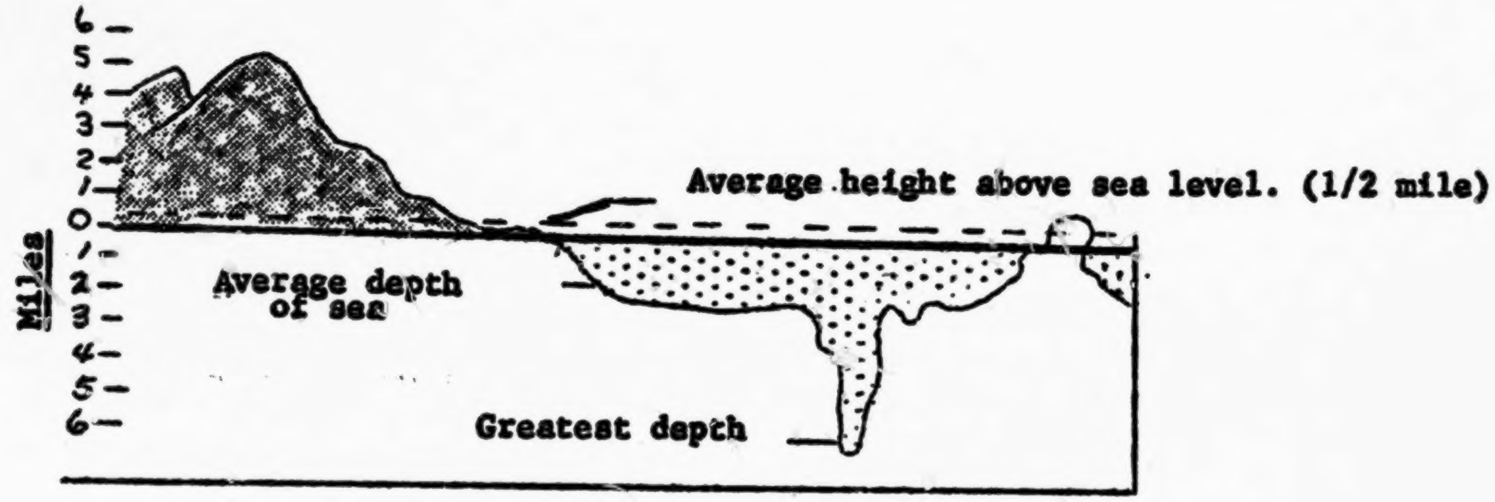

6
5
4
3
2
1
0
1
2
3
4
5
6
Miles
Average height above sea level. (1/2 mile)
Average depth of sea
Greatest depth

Figure 1

-Prepare a bulletin board entitled PATHWAYS ACROSS THE EARTH to represent migratory patterns of birds.
-Discuss a cave biome. Make a sketch of a food chain in a cave, as shown in figure 2.
Encourage some students to investigate other types of cave life and to prepare a class report.

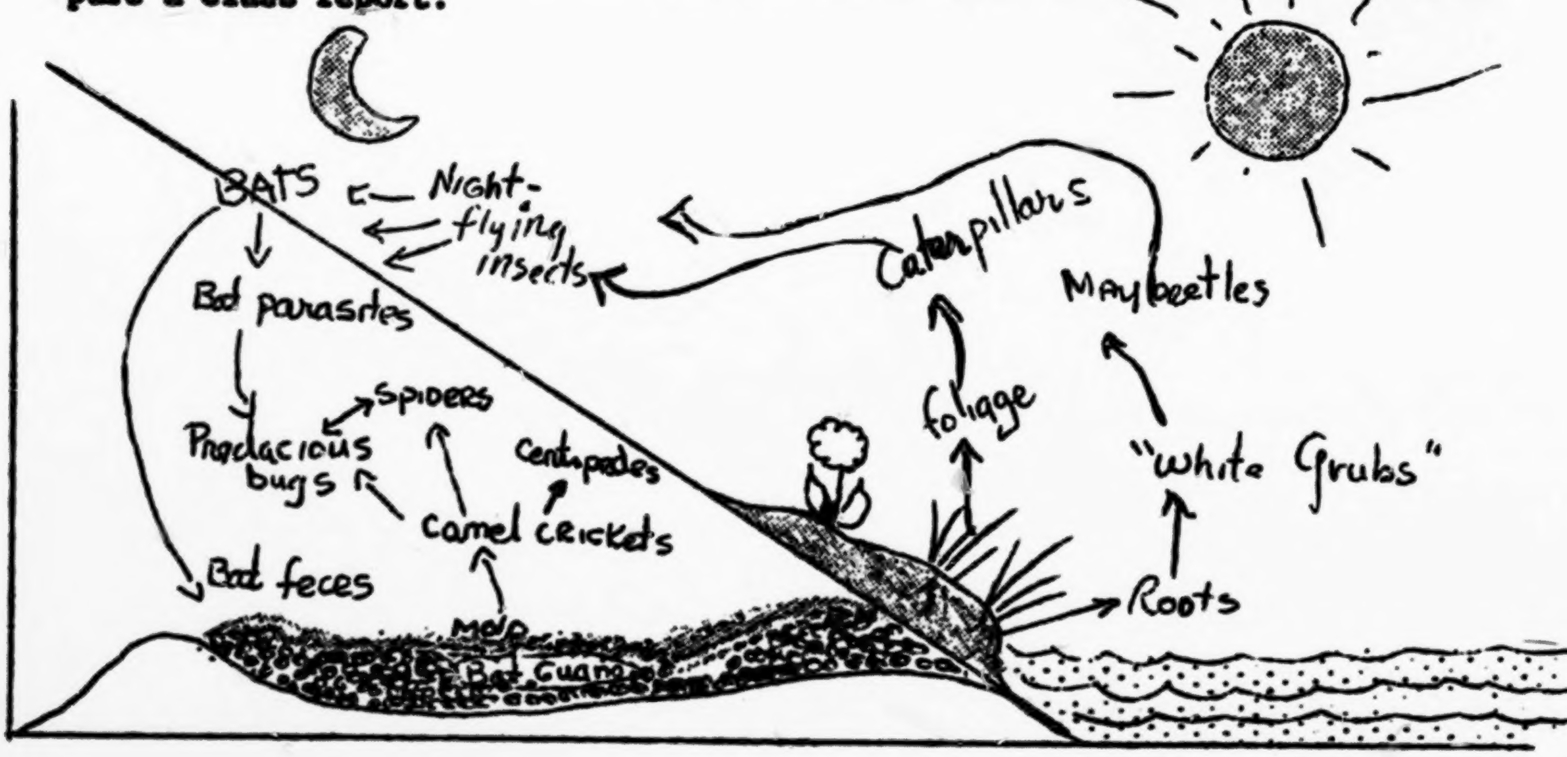

BATS
Night-flying insects
Caterpillars
Maybeetles
Bat parasites
foliage
Spiders
Predacious bugs
centipedes
"white Grubs"
camel crickets
Bat feces
Roots
Mold
Bat Guano

Figure 2

UNIT THREE: DISTRIBUTION OF LIFE

PLANNING AHEAD

-Assign two students to bring onions to class for growing roots in the study of mitosis.
-Prepare a bulletin board entitled MULTIPLICATION BY DIVISION to describe cell division and the process of mitosis.
-Encourage students to make trips to slow moving streams and ponds for collection of frog eggs and planaria.
-Assign some students to bring in living earthworms and keep them alive in the laboratory classroom.
-Prepare flannel board cutouts on gametogenesis and cleavage for a class demonstration.
-Locate and reserve active dry yeast, glucose solution, slides, and cover slips.
-Order Paramecia and Hydra from the Science Center.
-Locate science department slide collection and reserve slides showing binary fission in protozoa and budding in hydra.
-Prepare a culture of bread mold or green fruit mold.
-Assign students to bring in specimens of rhizomes of iris, bulbs of tulips or onion, corm from gladiolus, runners of the strawberry plant or quack grass, tuber of a potato, English ivy, white potato, Bryophyllum leaves, and carrot tops.
-Store a supply of paper cups and aluminum foil.
-Borrow grafting wax or locate paraffin for grafting experiments.
-Buy a small piece of liver and keep in the freezer section of the science department refrigerator. Food for the planaria.
-Locate and reserve sucrose, boric acid, distilled water, and mineral oil.
-Assign students to bring in flowers such as snapdragons, iris, lily, and others.
-Encourage several students to make collections of living sea urchins to bring back to class for fertilization experiments.
-Order live frogs from the Science Center. Try to induce female frogs to produce eggs to be used for artificial fertilization.
-Encourage students to bring in tropical fish for breeding experiments in the classroom.
-Order fertilized chicken eggs for laboratory experiment suggested on p. 370.
-Prepare a bulletin board on the structure of a chicken egg.
-Prepare NADI reagent as suggested on p. 374 for laboratory experiment.

UNIT THREE: DISTRIBUTION OF LIFE

BROADENING "CONTENT HORIZONS"

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ALLEN'S RULE

PURPOSE

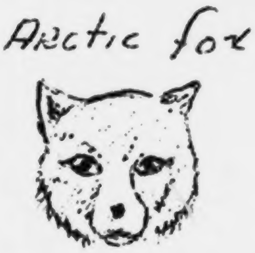
To understand the concept that within any one species, protruding parts such as tails, ears, or bills tend to be shorter in colder than in warmer climates.

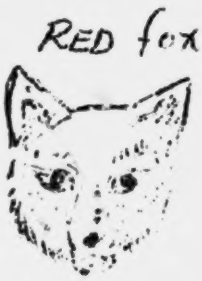
ACTIVITY MATERIALS

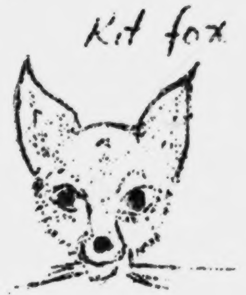
Cutouts or pictures of various animals illustrating Allen's rule.
Flannel board or bulletin board.
Ditto sheet (optional activity) of drawings below

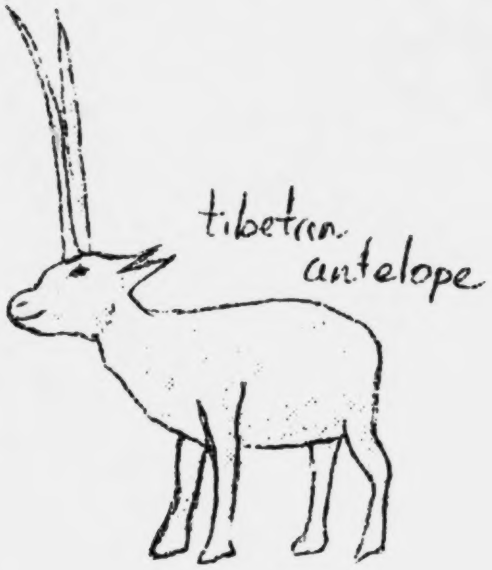
WHAT TO DO

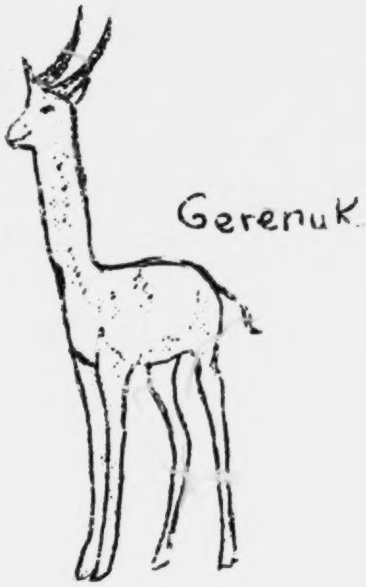
Display pictures or cutouts of various animals illustrating Allen's rule. Place these pictures on the bulletin board or flannel board. Students may wish to make reports on the survival value of this concept. Pass out ditto sheets of drawings shown below and students write a paragraph on significance of this principle in ecology. Students may wish to place various animals on a map to show the distribution according to Allen's rule.











Drawn after G. Simpson, et al., Life: An Introduction to Biology (New York: Harcourt, Brace, and World, 1957), p. 427. Permission granted by publishers.

BERGMANN'S RULE AND GLOGER'S RULE

PURPOSE

To understand the concept that within any one species, average size of individuals tends to be smaller in warmer climates and larger in colder climates. To understand the concept that within any one species, colors tend to be darker in warm, moist climates and lighter in cold, dry climates.

ACTIVITY MATERIALS

Pictures or cutouts of various animals illustrating Golger's rule and Bergmann's rule.

WHAT TO DO

Place pictures of a variety of animals of a similar species to illustrate Golger's rule and Bergmann's rule on the bulletin board. Students may wish to do their own research work and place pictures of animals on a blank map to illustrate these two generalizations in operation.

BARRIERS TO DISPERSION

PURPOSE

To learn and understand how geographic barriers may prevent dispersion of living organisms.

ACTIVITY MATERIALS

Pictures of Kaibab squirrel and the Grand Canyon
Ditto sheet of drawing shown below, or flannel board cutouts, or bulletin board material
Pictures or diagrams of the Panamanian land bridge World map

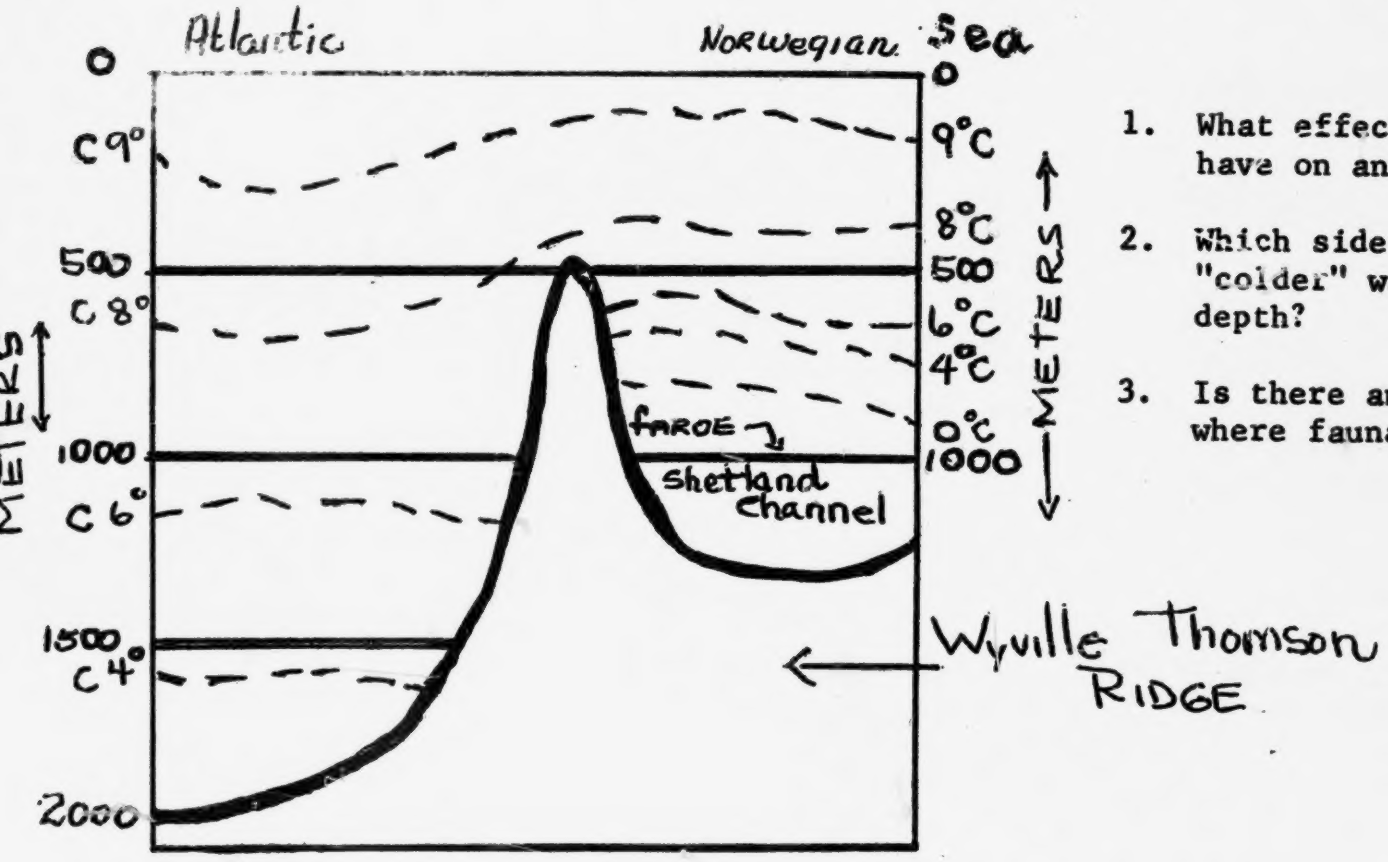
WHAT TO DO

Ask students to make a list of land masses that may be considered to be geographical barriers.

Direct students to make a list of other types of geographical barriers.

Demonstrate, by the use of the diagram below, the concept of barriers to dispersion.

List a number of reasons why the animals will not swim over the ridge.

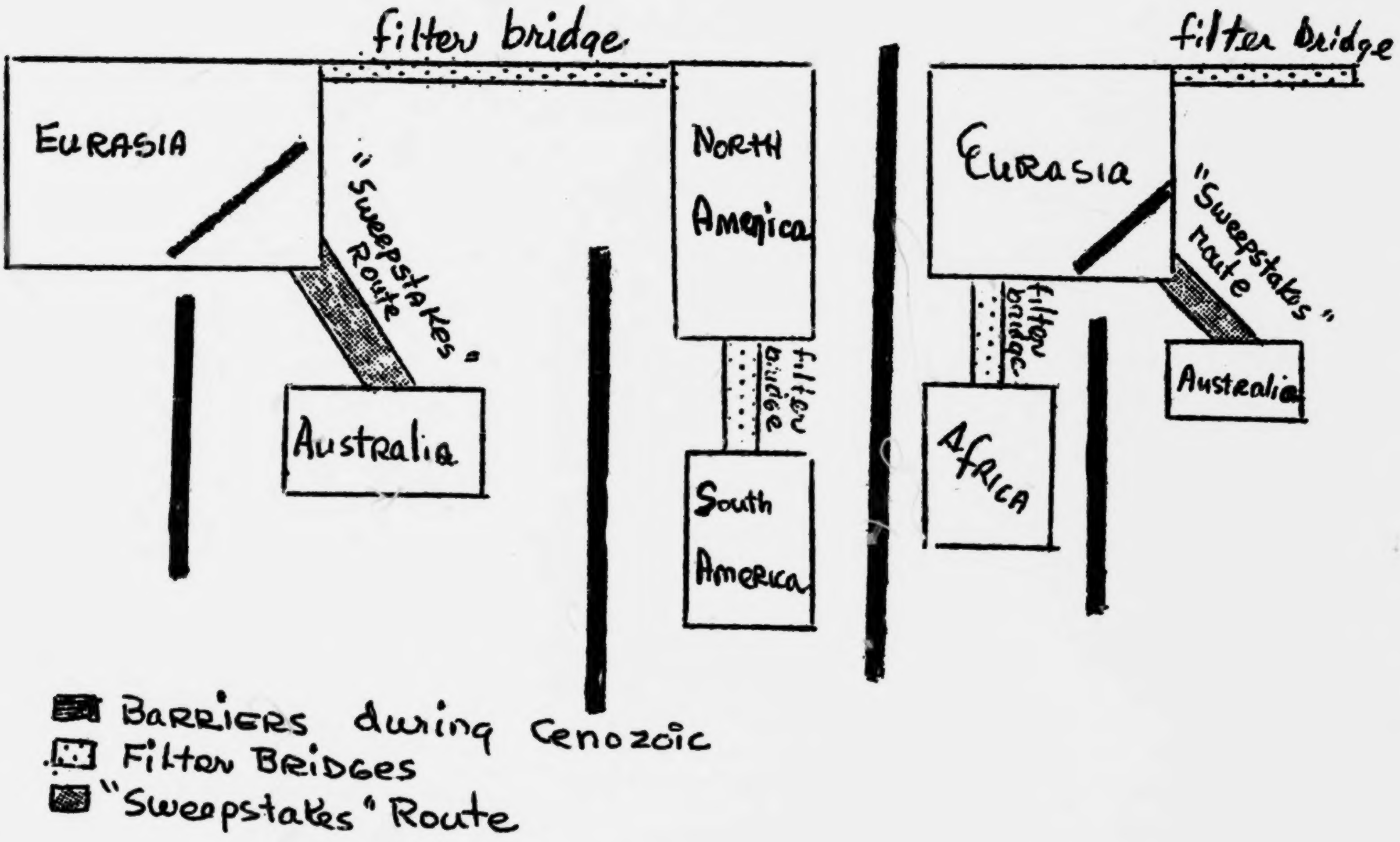

Atlantic
Norwegian Sea
0
C 9°
500
C 8°
METERS
1000
C 6°
1500
C 4°
2000
0
9°C
8°C
500
6°C
4°C
0°C
1000
METERS
Faroe
Shetland Channel
Wyville Thomson
RIDGE

1. What effect would this ridge have on animals of the area?
2. Which side of the ridge has "colder" water at a lesser depth?
3. Is there any area in diagram where fauna would mix?

Using a world map show the distribution patterns of the camel family. Show the past distribution and the present distribution by using shading and colored pencils.

Select a vertebrate animal or a tree that occurs in the Southern California area and that is divided into varieties or subspecies (geographic races). Look up the species in a handbook and study the map that shows the distribution of the geographic races. Attempt to explain the distribution of the species and why it may have become divided into geographic races.

Prepare a drawing on the chalkboard as shown below. Give an explanation of filter bridges, " sweepstakes" route and barriers occurring during the Cenozoic.


filter bridge
EURASIA
"Sweepstakes" Route
Australia
North America
filter bridge
South America
filter bridge
Eurasia
"Sweepstakes" route
filter bridge
Africa
Australia
Barriers during Cenozoic
Filter Bridges
"Sweepstakes" Route

Drawn after G. Simpson, et al., Life: An Introduction to Biology (New York: Harcourt, Brace, and World, 1957), p. 720. Permission granted by publishers.

UNIT THREE: DISTRIBUTION OF LIFE

EFFECTS OF ALTITUDE AND LATITUDE

PURPOSE

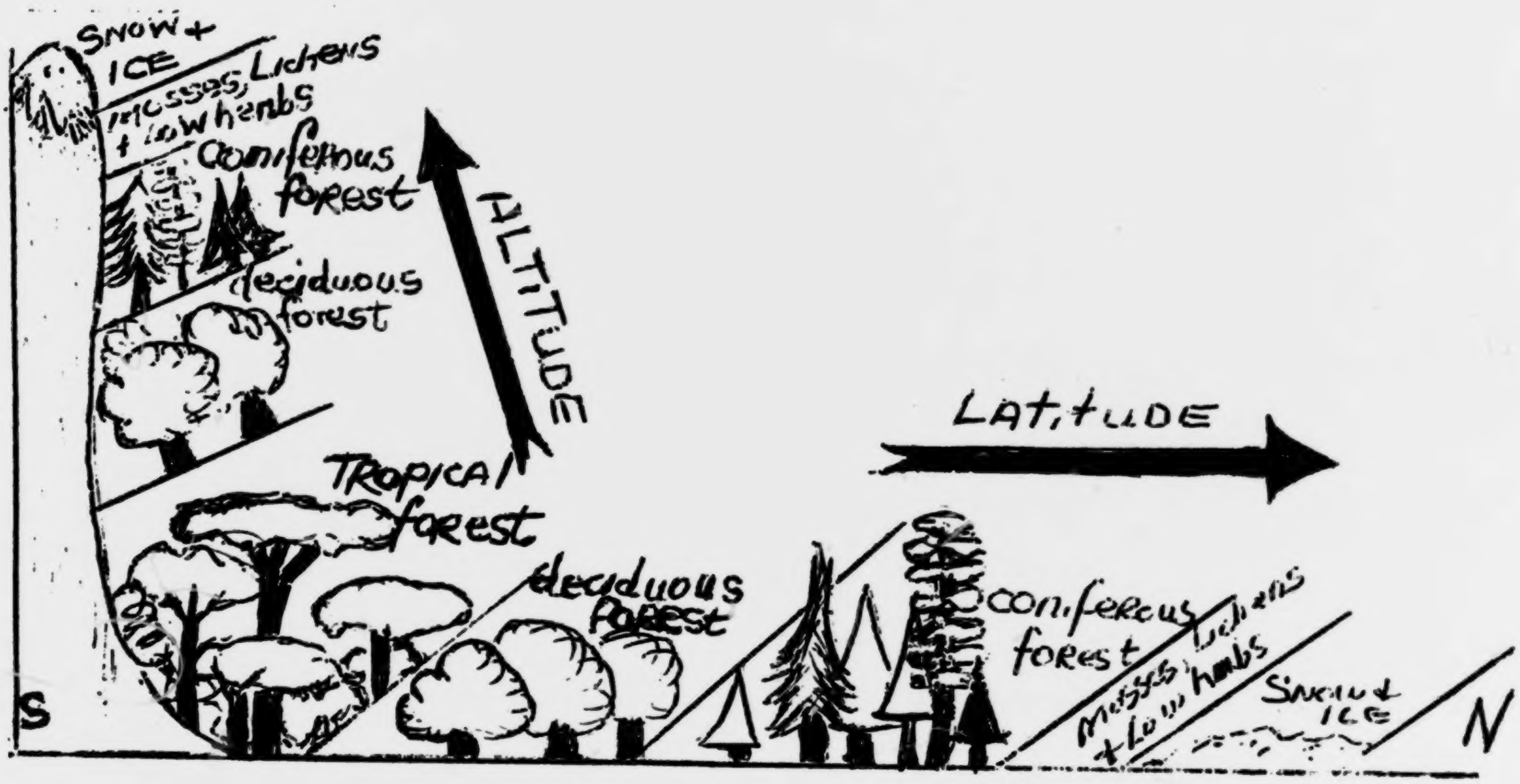
To understand and learn that latitude and altitude are limiting factors in the distribution of living organisms.

ACTIVITY MATERIALS

Drawing of diagram shown below
Bulletin board
Ditto material

WHAT TO DO

Students study diagrams on bulletin board display or ditto material. Students discuss zonation of vegetation. What differences can be noted on southwest slope and northeast slope? Study the profile in Figure 2. Where are forests found? Are there any areas not forested? Why? What has affected this distribution? Study Figure 3. What comparisons can be made in relation to perpetual snow level? Tree line level? Coniferous forests?


SNOW + ICE
mosses, Lichens + Low herbs
Coniferous forest
deciduous forest
ALTITUDE
TROPICAL forest
deciduous FOREST
LATITUDE
coniferous forest
mosses, Lichens + Low herbs
Snow + ICE
S
N

Moist air currents in relation to altitude affect distribution of forests.

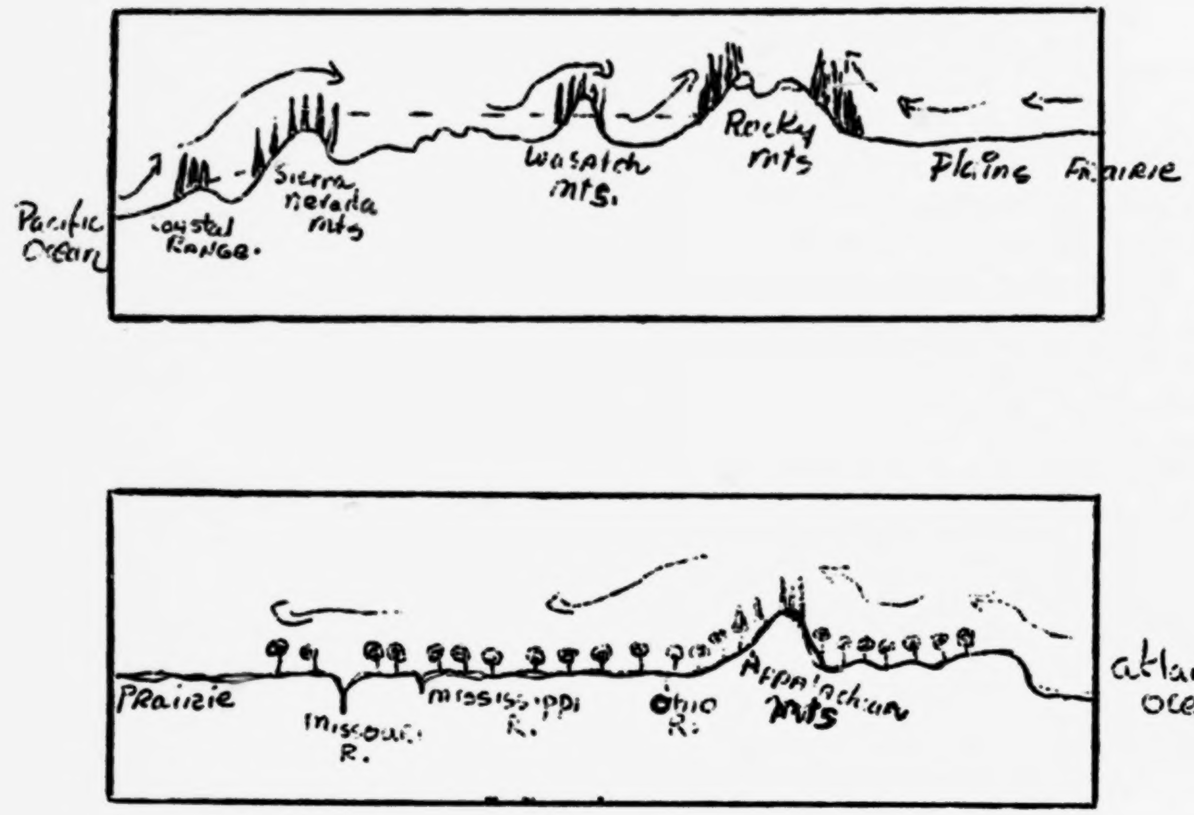
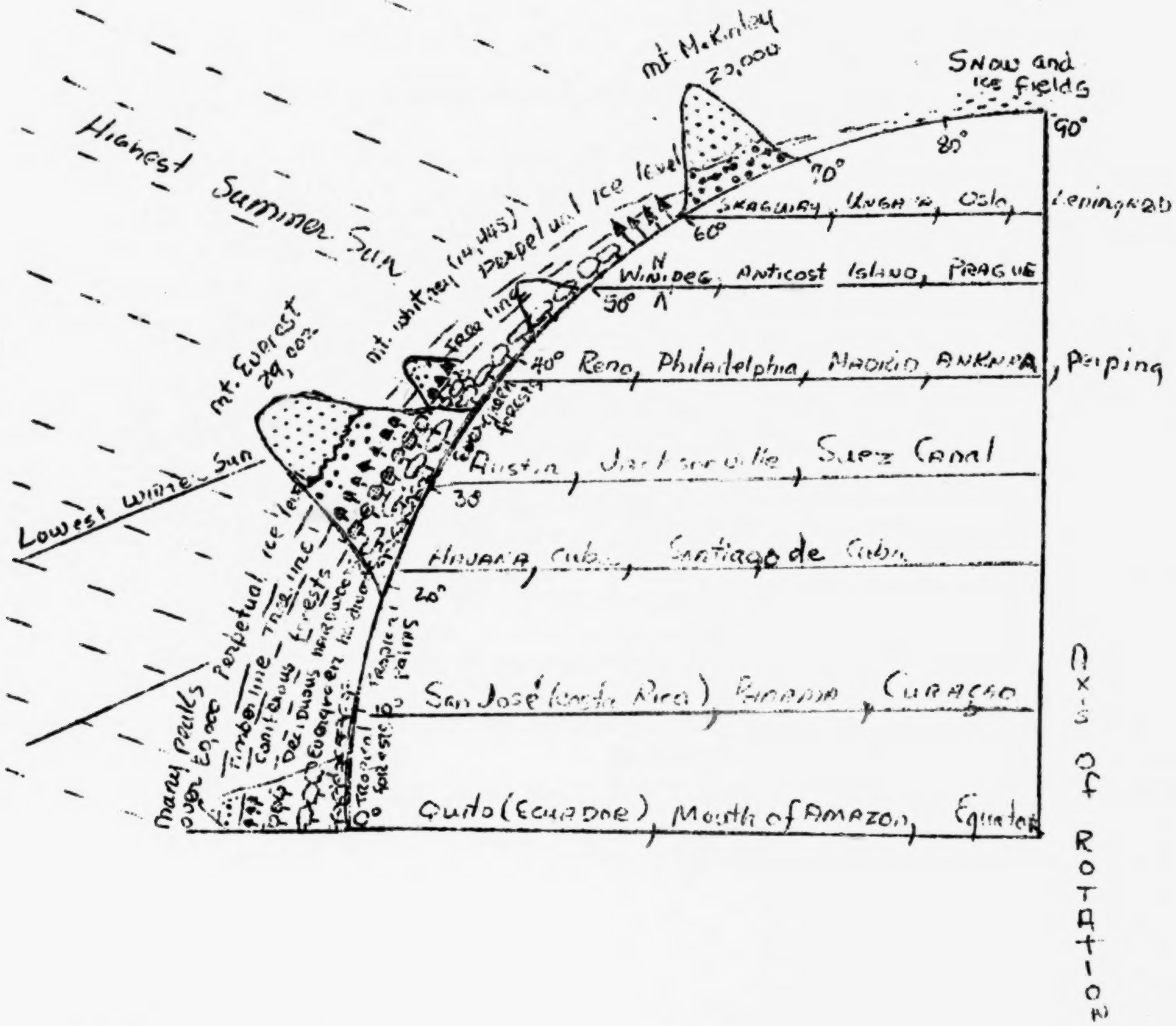

Pacific Ocean
coastal RANGE.
Sierra nevada mts
Wasatch mts.
Rocky mts
Plains
Prairie
Prairie
missouri R.
mississippi R.
Ohio R.
Appalachian Mts
atlantic ocean

Figure 2

United States Department of Agriculture Yearbook. Climate and Man. 1941.

EFFECTS OF ALTITUDE AND LATITUDE


Highest Summer Sun
Lowest winter Sun
mt. McKinley 20,000
Snow and ice fields
mt. whitney (14,495)
perpetual ice level
Tree line
mt. Everest 29,002
Many peaks over 20,000
Perpetual ice level
Timberline
Tree line
Coniferous forests
Deciduous hardwoods
Evergreen hardwoods
Tropical forests
Tropical rains
90°
80°
70°
60°
50°
40°
30
20°
10°
0°
N
Skagway, Ungava, Oslo, Leningrad
Winipeg, Anticost Island, Prague
Reno, Philadelphia, Madrid, Ankara, Peiping
Austin, Jacksonville, Suez Canal
Havana, Cuba, Santiago de Cuba
San José (Costa Rica), Panama, Curaçao
Quito (Ecuador), Mouth of Amazon, Equator
Axis of Rotation

Drawn after Lorus and Margery Milne, Biotic World and Man. Englewood Cliffs, New Jersey: Prentice-Hall, 1958), p. 384. By permission of Prentice-Hall, Inc. publishers.

CONSTRUCTION OF HABITATS

PURPOSE

To illustrate the principles of distribution by creating a specific habitat in the classroom laboratory. Students work in groups.

ACTIVITY MATERIALS

Several aquaria with glass tops
Small living animals for habitats
Rocks
Sand, rich soil, peat moss, loam
Plants such as cacti, ferns, mosses, liverworts, and others

WHAT TO DO

Construction of a woodland
Collect some rich dirt from a woods or mix equal parts of humus and loam. Fill the bottom of the terrarium about 2 inches deep. Design the woodland habitat so that it has a small ravine located near the center. Use two pieces of shale or limestone and slope soil up either side of the ravine to form the banks. Plant the terrarium with mosses, very small ferns, and other plants of the deep woods. Some liverworts might be planted along rock ledges of the ravine. Add snails, small toads, and salamanders. Water the habitat every two or three days, keeping the soil moist but not wet.

Construction of a desert
Mix equal parts of loam and sand and place a layer about two inches deep in the bottom of the terrarium. Plant small cacti in the sand, being sure to spread the roots. Build a small rock formation (using rocks similar in color to those of a desert) in one end and conceal a pan of water behind it. Place small horned lizards, collared lizards, and other desert species.
Water the desert about once a week, but keep a supply of water for the lizards at all times.

Construction of a bog
Place a two-inch layer of peat or raw sphagnum moss mixed with loam in the bottom of the terrarium. Cover the peat with living sphagnum moss. A small pool of open water near the center of the habitat may be constructed by removing the dirt and sphagnum moss. Plant pitcher plant, Venus' flytrap and sundew. Water the bog frequently so that the layer of sphagnum moss is moist but not submerged. Add a salamander, small turtle, and some small frogs.

Construction of a tropical habitat
Place two inches of rich loam-mixed humus in a terrarium. Plant the habitat with small ferns, and vines, such as Philodendron. The leafy top cut from a pineapple will often grow roots and give a tropical atmosphere. Small orchids may be included if the terrarium is kept warm, especially at night. Add animals such as chameleons and small harmless snakes.

Adapted from James Otto, and Sam Blanc. Biology Investigations: A Workbook and Laboratory Manual. (New York: Henry Holt Co., 1956) pp. 48-49. Reprinted by special permission of the publisher from Biology Investigations, by Otto and Blanc, 1956, by Holt, Rinehart and Winston, Inc.

UNIT THREE: DISTRIBUTION OF LIFE

FORESTS

PURPOSE

To learn the geographical location of the major forests of the world and their distribution patterns.

ACTIVITY MATERIALS

World map wall chart
Blank world map study chart
Colored pencils
Atlases, Encylopedias, other reference books

WHAT TO DO

Using reference books, establish the distribution of forests around the world. Include a color key for: broadleaf evergreens (rain forests), needle-leaf evergreens (pine, fir, spruce), mixed forest (beech, maple, oak), broadleaf deciduous (oak, elm, and ash), grasslands, shrublands, needle-leaf deciduous.

Using another symbol or shading, show the location and distribution of mountain ranges around the world.

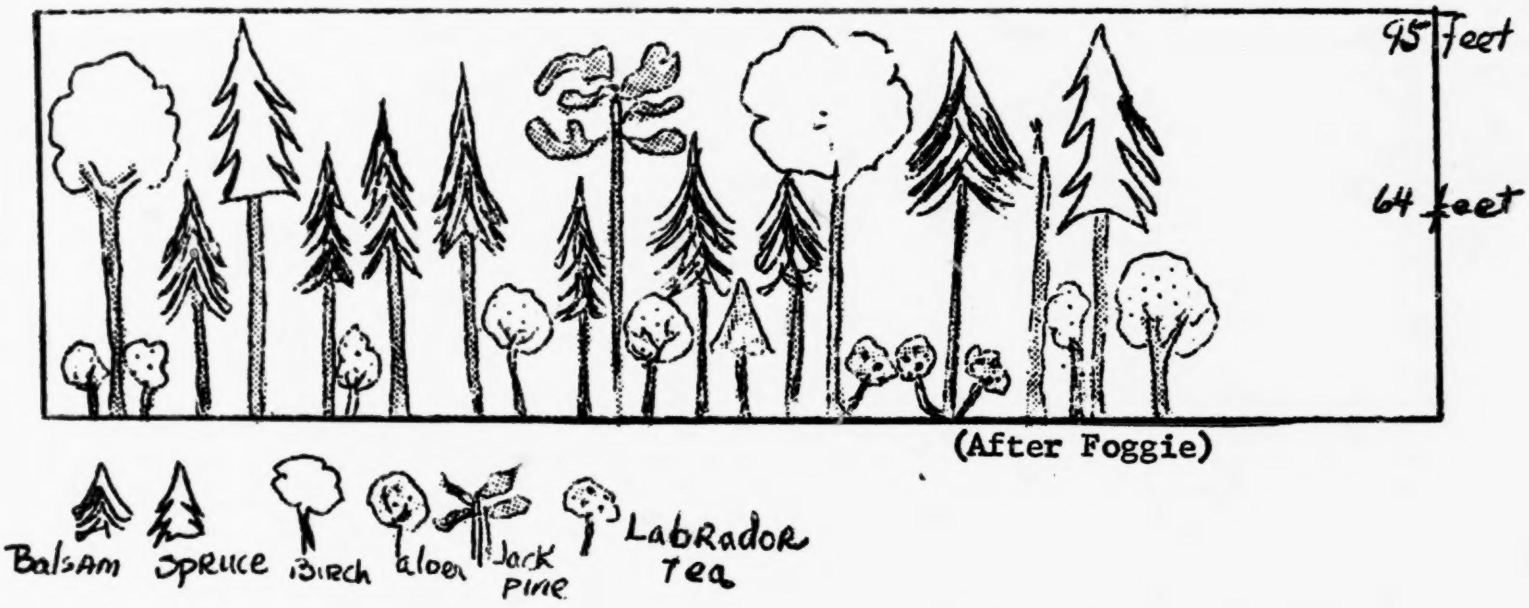
STRATIFICATION OF FORESTS

PURPOSE

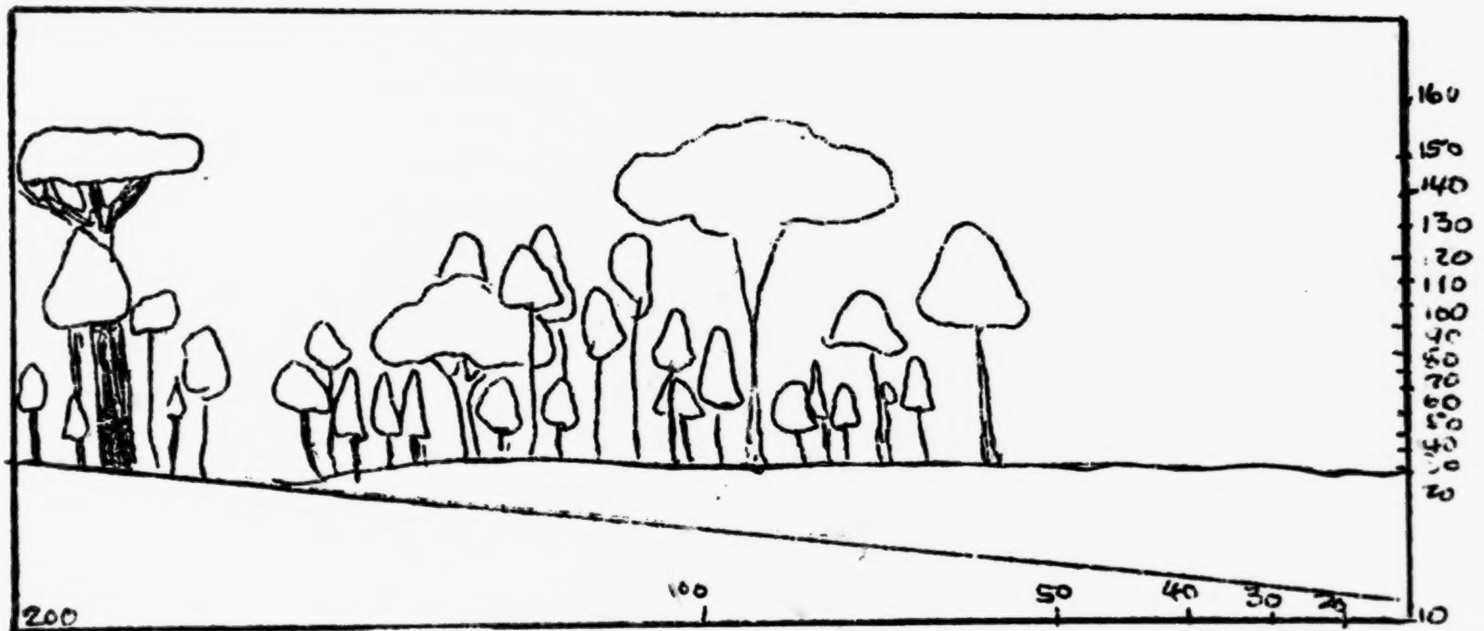
To learn and understand the concept of stratification as it occurs in forests and how this affects the distribution of living organisms.

ACTIVITY MATERIALS

Diagrams of forest stratifications as shown below, or other diagrams.
Textbook and other reference materials.


95 feet
64 feet
Balsam
Spruce
Birch
alder
Jack pine
Labrador Tea

(After Foggie)


160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
200
100
50
40
30
20
10

(After Kendeigh)

Drawn after W. C. Allee, et al., Principles of Animal Ecology (Philadelphia, Pa.: Saunders, 1949), p. 483. By permission of publishers.

THE DESERTS: THEIR LOCATIONS AND CAUSES

PURPOSE

To learn and understand how deserts are formed and their geographical locations.

ACTIVITY MATERIALS

Encylopedias, atlases, and other references (Leopold, A. S. The Desert. New York: Time Inc., 1961.)
Wall chart of the world
Blank world maps
Colored pencils

WHAT TO DO

Using some symbol or colored pencil, mark in the known major deserts of the world on the blank map, indicate the ocean currents (are they warm or cold?), and the wind currents.

What factors contribute to form a desert?
Why are great quantities of salts of sodium, potassium and other soluble minerals found in desert soils?
Which desert is considered to be the coldest? Which is considered to be the hottest? Why?
Is there any pattern to the distribution of deserts on world map?
Which desert is considered to be the largest? Which is considered to be the smallest?

SEASHORE PROFILE

PURPOSE

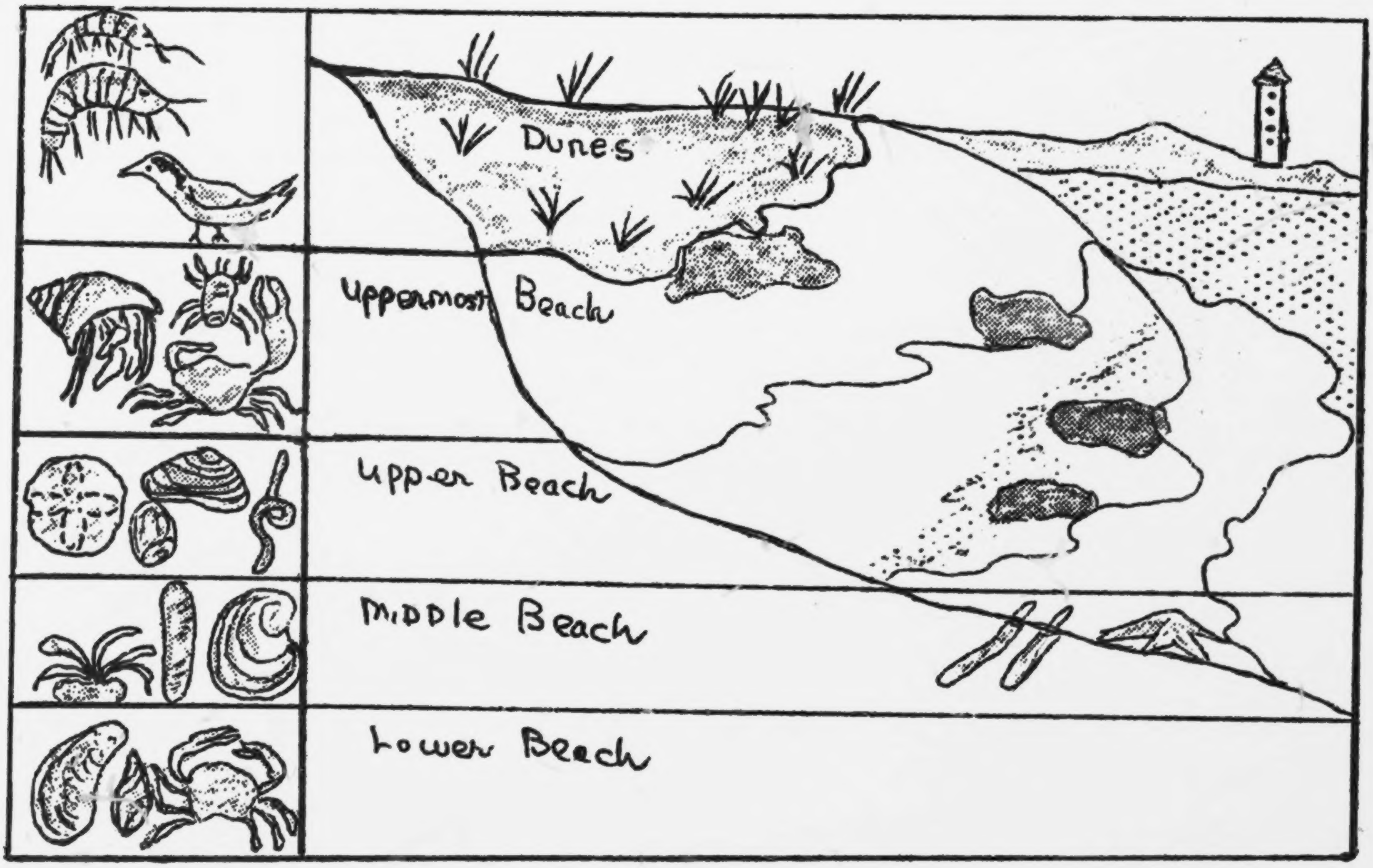
To illustrate the principle of distribution at the seashore through a seashore profile.

ACTIVITY MATERIALS

Reference books, textbooks, encyclopedias
Ditto sheet of profile shown below

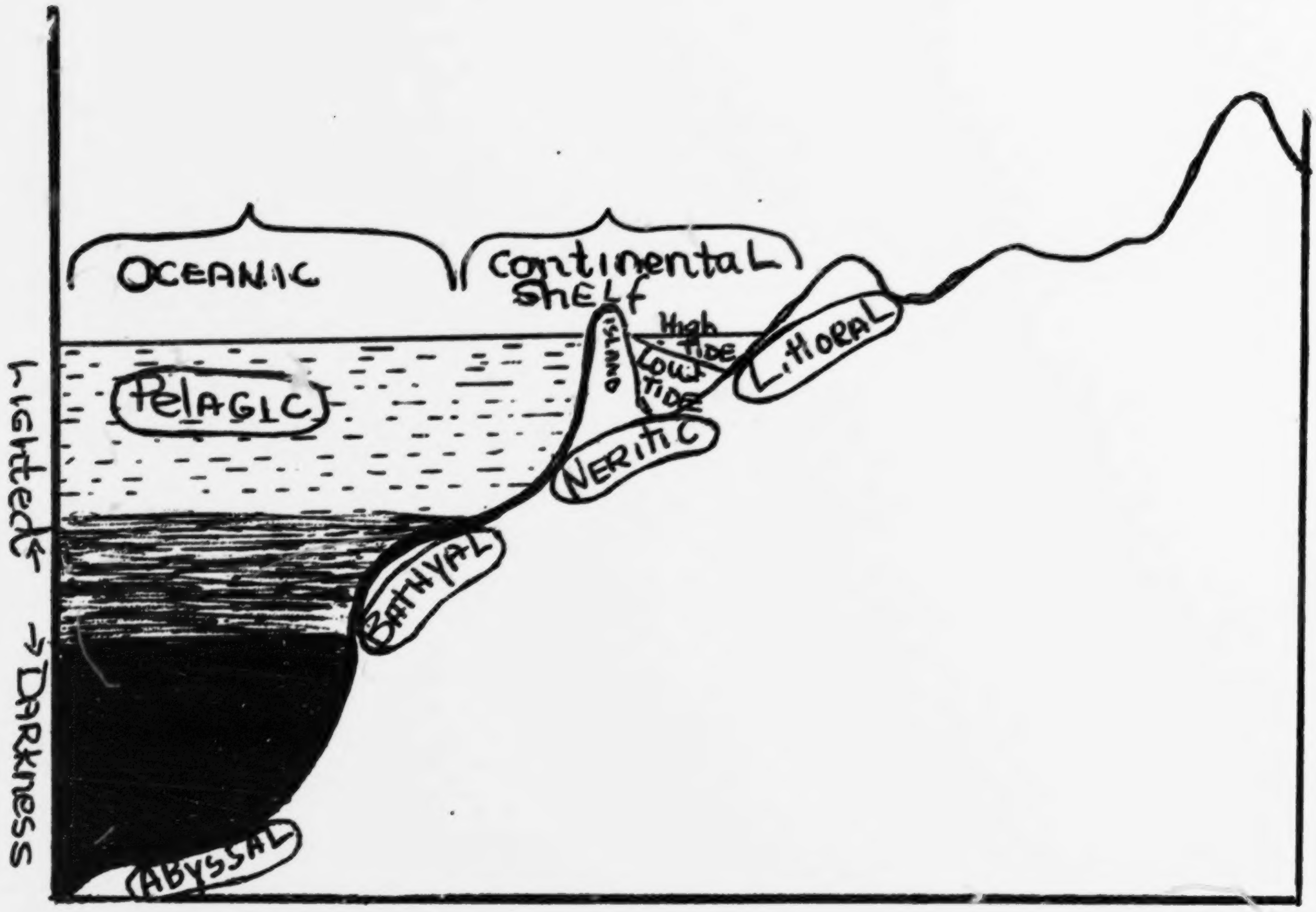
WHAT TO DO

Students give the general characteristics of each level of the seashore profile and add typical plants and animals of that level.


Dunes
Uppermost Beach
Upper Beach
Middle Beach
Lower Beach

Drawn after Zim, Herbert and Lester Ingle. Seashore. New York: Golden Press, 1955, p. 14.

PROFILE OF THE SEA


OCEANIC
Continental Shelf
Pelagic
Island
High Tide
Low Tide
Littoral
Neritic
Bathyal
Abyssal
Lighted
Darkness

UNIT THREE: DISTRIBUTION OF LIFE

ZONATION ON A ROCKY SHORE

PURPOSE

To understand that the difference of a steeply sloping rocky shore may be compared to that of habitats that are thousands of feet apart in the climatic zones of mountains.

ACTIVITY MATERIALS

2 X 2 Kodachrome slides of actual pictures of habitats of a steeply sloping rocky shore
Ditto sheet of diagram shown on following page
A list of questions to be answered by students

WHAT TO DO

Take pictures or borrow slides of rocky shore lines to show zonation. Students may make a three-dimensional model of zonation on a rocky slope, as shown in diagram on following page:

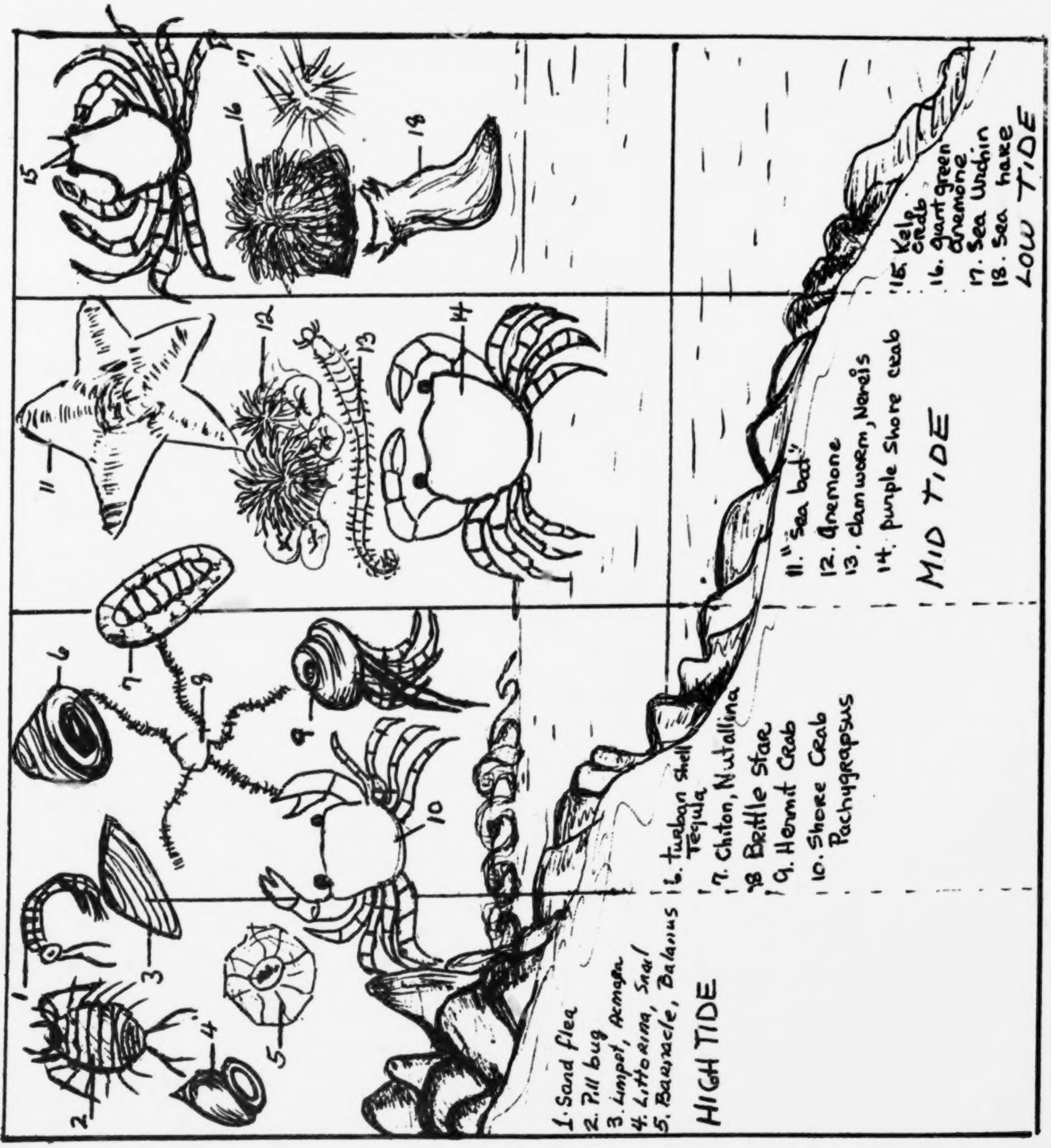
Which of the three zones listed in the drawing are moistened by spray and the highest tides?

Which of the three zones are below the water mark?

Which of the three zones are covered and uncovered by the tides?

What factors contribute to the sharp differences exhibited on a few feet of a steeply sloping rocky shore?

ZONATION OF A ROCKY SLOPE


1. Sand flea
2. Pill bug
3. Limpet, Acmaea
4. Littorina, Snail
5. Barnacle, Balanus
HIGH TIDE
6. turban shell Tegula
7. Chiton, Nutallina
8. Brittle Star
9. Hermit Crab
10. Shore Crab Pachygrapsus
11. "Sea bat"
12. Anemone
13. clamworm, Nereis
14. purple Shore crab
MID TIDE
15. Kelp crab
16. giant green anemone
17. Sea Urchin
18. Sea hare
LOW TIDE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

UNIT THREE: DISTRIBUTION OF LIFE

OCEANS - THEIR LOCATIONS AND GEOGRAPHY

PURPOSE

To illustrate the geography of oceans of the world and to show by use of a profile the important geographical locations.

ACTIVITY MATERIALS

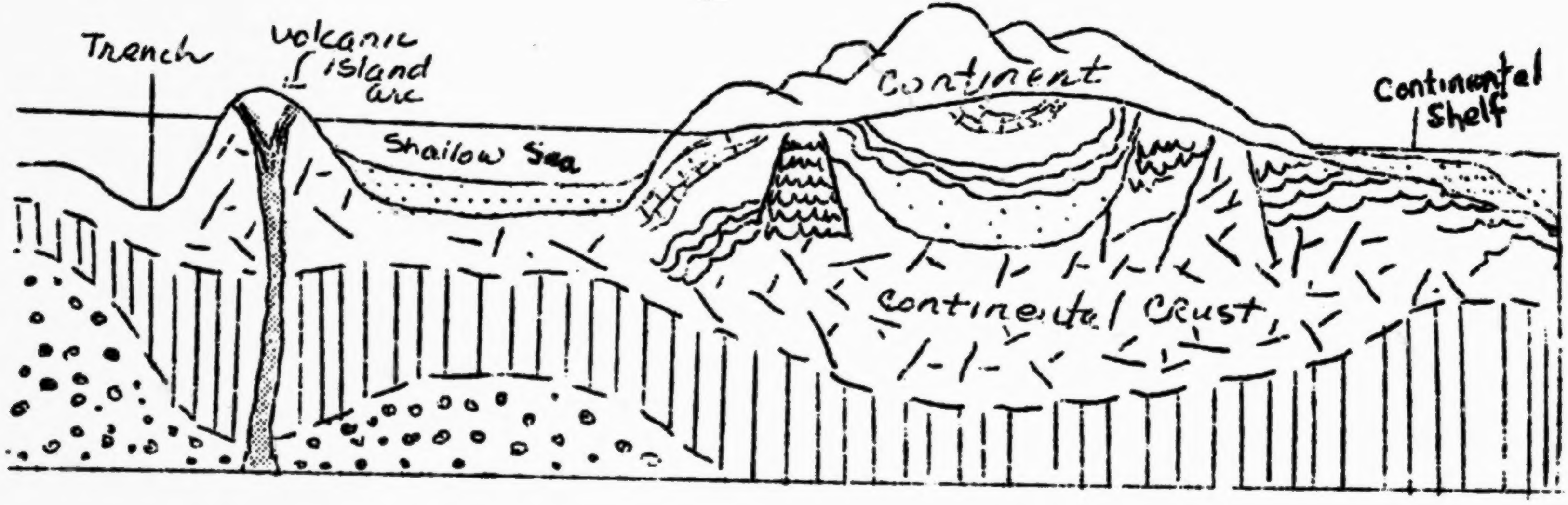
A large poster or a drawing on the chalk board of diagram shown on following page
Reference books, encylopedias, textbook and Engel, Leonard, The Sea. New York: Time, Inc. New York, 1961

WHAT TO DO

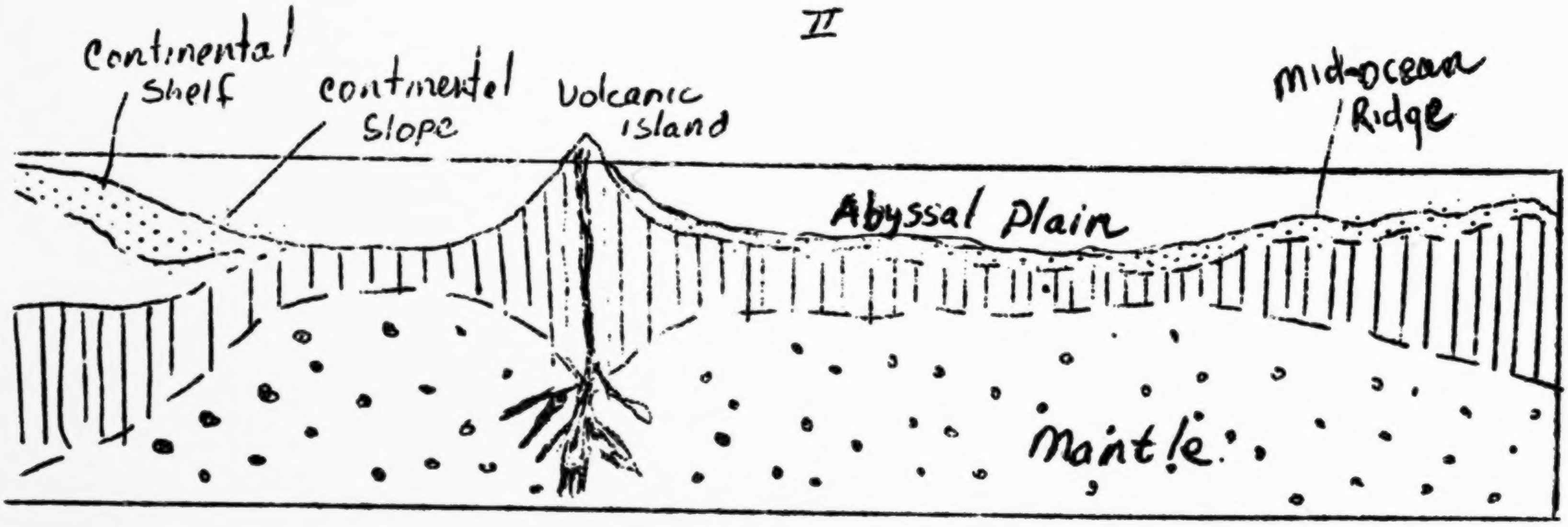
Prepare a large poster or make a drawing on the chalk board of diagram shown on following page.

Discuss some of the following topics:
- a. What is a volcanic island arc?
- b. How is a trench formed?
- c Do all continents have a continental shelf and slope?
- d. What is a guyot?
- e. What is the significance of the mid-ocean ridge?
- f. What is the significance of the mid-ocean rift?
- g. What is the difference in thickness between the continental crust and the oceanic crust?
- h. What is characteristic of the abyssal plain?
- i. What contributes to the formation of the continental shelf?
- j. What is a turbidity current? How have these currents been able to carve canyons and gorges?

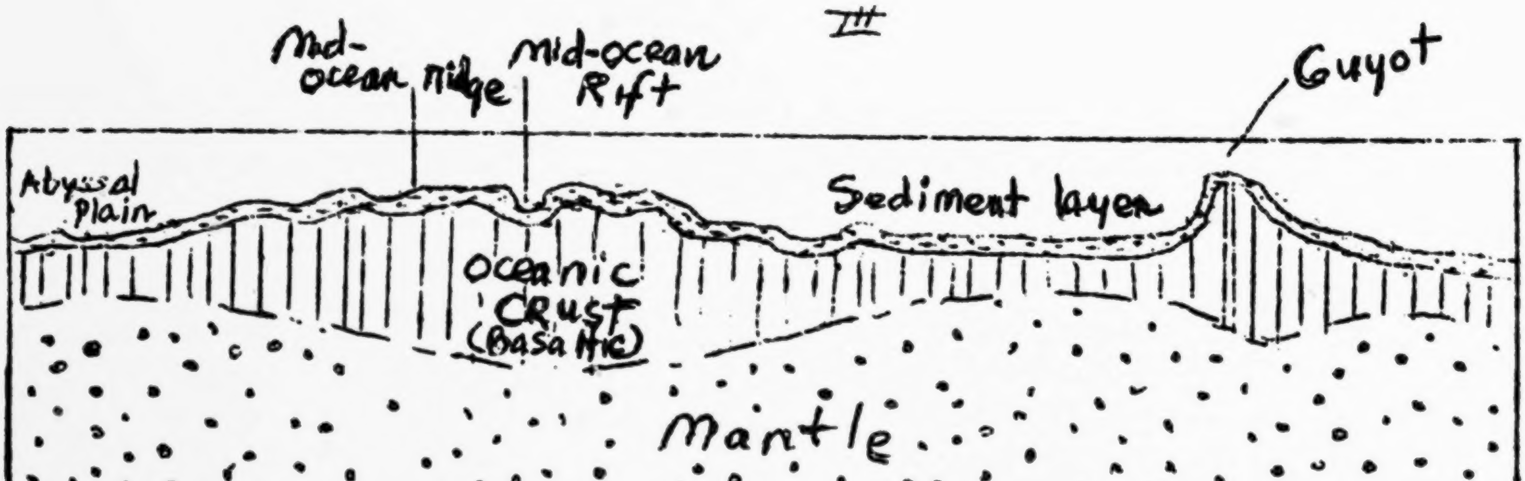
I


Trench
Volcanic island arc
Continent
Continental Shelf
Shallow Sea
continental Crust

II


Continental shelf
continental slope
Volcanic island
Mid-ocean Ridge
Abyssal Plain
Mantle

III


Mid-ocean ridge
Mid-ocean Rift
Guyot
Abyssal Plain
Sediment layer
Oceanic Crust (Basaltic)
Mantle

Drawn after Engel, Leonard. The Sea. New York: Time, Inc., 1961. pp. 56-57.

CORAL GROWTHS

PURPOSE

To learn and understand how the temperature of ocean currents determines the distribution of coral growths.

ACTIVITY MATERIALS

World geography textbook or atlas, encyclopedias, books on oceanography
Colored pencils
World map (blank)

WHAT TO DO

Mark on the blank world map with a distinct mark or color the coral barrier reefs, fringing reefs, atolls in all marine waters.

Indicate the major depths of the oceans. Use some symbol or shading to indicate this feature.

Mark in the major currents, using red pencil for warm currents and blue pencil for cold currents. Some of the currents to be considered are California, Humboldt, Labrador, Subarctic, North Equatorial and South Equatorial, West Wind Drift, Gulf Stream, Brazil, North Atlantic, Equatorial Counter Current, Antilles, Kuroshio, Florida, Guinea, and others.

If possible record the surface water temperature of oceans at places where the depth is less than 2 miles.

What are the relationships of currents, land masses, water depth and temperature to the growth of coral?

What kinds of dissolved chemicals and other materials are found in water flowing over corals?

Where is the greatest known barrier reef? Why is it located there?

What are the differences between fringing, barrier and atolls?

On what sides of the land masses do you find most of the reefs growing?

Adapted from High School Biology, Green Version-- The Laboratory, Part Two, Exercise 8.2, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

UNIT THREE: DISTRIBUTION OF LIFE

From your research are you able to determine the geographical latitude and longitude of most coral reefs?

Give a brief explanation of Darwin's theory of coral reef formations?

What is so unusual about the formation of Bermuda?

Is there any reason for the absence of coral growths in estuaries and soft-bottomed bays?

BIOLOGY 1

RESOURCE UNIT

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

LOS ANGELES CITY SCHOOLS
Division of Instructional Services
Curriculum Branch
1963

ACKNOWLEDGMENTS

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AVERILL M. CHAPMAN
Administrator of Curriculum

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

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UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

USE OF THE RESOURCE UNIT

This resource unit has been prepared and developed for use by biology teachers in Los Angeles City Schools. It is intended that this resource unit be filed in a three-hole loose leaf binder by the teacher. It is hoped that this unbound material will be of greater use to the teacher and will be more adaptable to making changes in sequence and providing for additions and deletions.

The Outline Course of Study for Biology 1, publication SC 597, contains general information vital to the teaching program and should be referred to often. General safety regulations, teaching patterns, and point of view are some of the important sections of this publication. The teacher will find it helpful to use both the Outline Course of Study and the Resource Unit. The Outline Course of Study is available from the Curriculum Branch.

How To Use The Resource Unit

Outline of Content

The teacher should briefly review the pages of this section to receive an over-all view of the entire unit content.

Estimated Time Block

After reviewing the outline of content for this unit, the teacher should make note of the suggested time allotment. The teacher should be encouraged to prepare a block of squares showing the four, five or six week period and plan his own pattern of time allotment for subject matter. The teacher need follow only the estimated time block.

Concepts to Consider

Read the concepts to consider at the beginning of this unit. These concepts are major generalizations of subject content and should serve as guidelines for instruction.

Teaching Approach (Methods and Activities)

The teacher will find this section to be a suggested direction or path for instruction. The approach is sequential and may be used at the discretion of the teacher. It will be noted that there are many more suggestions for teaching than can be carried out for a particular time block. The teacher is charged with the responsibility of selecting those activities best suited to the ability level of his students.

Depth Probe

This section provides three general levels of ability for slow students, average students, and more able students. The teacher may use any or all of these activities. An attempt has been made to alert the teacher to activities that are basic to the subject content. Note that terms such as "optional" or "basic" have been used in this respect. All activities to be done will be decided upon by the individual teacher according to materials and student abilities, regardless of established color code.

"Tools" for Extending Concepts

This section is intended to supply the teacher with enrichment ideas for highly motivated students. Remember that many more ideas have been given than can possibly be carried on, so select those activities that are most suitable.

Planning Ahead

This section is intended to alert the teacher to materials needed for activities coming in following sections of this unit and other units. Pay particular attention to this section on ordering materials from the Science Center, since a two-weeks-in-advance order is necessary for many of the fresh materials.

Broadening "Content Horizons"

This section is divided into three parts. The first part is an area devoted to references to be used by the teacher to gain a broader background for subject content. The second part is an area devoted to references to be used for students, and care has been taken in recommending those books that are generally found in school libraries. The third part is an area devoted to the textbook reading assignments for the particular subject content. The two textbooks cited are Smith, Ella Thea, Exploring Biology, 4th and 5th Editions; and Moon, Otto, and Towle, Modern Biology, 1960 and 1963 Editions.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

CONTENT OUTLINE

I. Continuity of Life
  A. Cell Reproduction
    1. Mitosis
    2. Meiosis
  B. Asexual Reproduction
  C. Sexual Reproduction
  D. Embryology
    1. Differentiation
    2. Growth Patterns

II. Patterns in Heredity
  A. Chromosome and Heredity
  B. Nature of the Gene
  C. Reproduction of Genetic Material and Gene Action
  D. Mechanism of Heredity

III. Change in Living Things
  A. Mechanism of Evolution
    1. Early Ideas (Aristotle, Lamarck, and Others)
    2. Natural Selection (Darwin, Wallace, and Mendel)
    3. Genes and Population (Speciation)
    4. Mutations (De Vries)

5. Adaptive Radiation and Convergence, Parallelism (Survival Factors)
    - a. Food Getting
    - b. Mimicry
    - c. Hibernation and Aestivation
    - d. Migration
    - e. Coloration and Camouflage
    - f. Mating and Nesting

B. Evidence of Biologic Change
  1. Extinction and Replacement Theory
  2. Embryology
  3. Vestigial Organs
  4. Industrial Melanism (D.D.T. Resistance, Antibiotic Resistance, etc.)
  5. Geologic Time Table and Fossils
    - a. Archeozoic
    - b. Paleozoic
    - c. Mesozoic
    - d. Cenozoic

C. Changes in Primates
  1. Primate Background
    - a. Physical Environment
    - b. Biotic Environment
  2. Hominid Radiation

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

TEXTBOOK REFERENCE SUMMARY

Smith, Ella Thea

Exploring Biology 4th Edition

Continuity of Life	pp. 352-402
Patterns in Heredity	pp. 404-426
Changes in Living Things	pp. 418-496

Exploring Biology 5th Edition

Continuity of Life	pp. 486-513
Patterns in Heredity	pp. 514-543
Changes in Living Things	pp. 546-599

Moon, Otto, and Towle

Modern Biology 1960 Edition

Continuity of Life	pp. 608-618 and 200-225
Patterns in Heredity	pp. 618-655
Changes in Living Things	pp. 635-688

Modern Biology 1963 Edition

Continuity of Life	pp. 219-414
Patterns in Heredity	pp. 618-655
Changes in Living Things	pp. 635-668

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

MASTER MATERIALS LIST

EQUIPMENT

- Aquarium (8 or 15 gals.)
- Incubator
- Microscopes
- Stereomicroscopes

SUPPLIES

Non-Consumable

- Bunsen burner
- Calipers
- Electric light and socket
- Filter for aquarium
- Flannel board
- Heater for aquarium
- Pans, Enamel
- Scalpels
- Scissors
- Test tube racks

Consumable

- Glassware
  - Battery jars
  - Beakers
  - Bottles, plain-widemouthed
  - Culture dishes
  - Finger bowls
  - Glass panes
  - Glass rods
  - Milk bottles, ½ pint (or baby food jars)
  - Petri dishes
  - Pipettes (eye dropper type)
  - Slides and cover slips
  - Syracuse dishes
  - Test tubes
  - Thermometers
  - Watch glasses
- Chemicals
  - Aceto-carmine stain
  - Alpha-naphthol
  - Calcium nitrate
  - Colchicine
  - Dimethyl-p-phenylenediamine
  - Distilled water
  - Ferric phosphate
  - Hydrochloric acid
  - Magnesium sulphate
  - Phosphate buffer
  - Potassium chloride
  - Potassium dihydrogen phosphate
  - Potassium nitrate
  - Sodium hydroxide
  - Sucrose solutions
- Other Materials
  - Agar, nutrient
  - Bags, paper
  - Beads, plastic or wood
  - Beads, poppit
  - Camel's hair brushes
  - Cheesecloth
  - Clay, modeling
  - Construction paper (various colors)
  - Corrugated paper
  - Cotton, absorbent
  - Dissecting needles
  - Floral wire tape
  - Flower pots
  - Forceps
  - Fossil specimens
  - Gravel
  - Graph paper
  - Humus
  - Mineral oil
  - Paper cups
  - Paper towels
  - Paraffin
  - Pattern paper, black

- Plaster of Paris
- Pipe cleaners
- Prepared slides, such as
  - Mitosis (Ascaris and Whitefish)
  - Hydra budding
  - Paramecium in Binary Fission
  - Sickle cell anemia
  - Human Blood cells
  - Ovarian section
  - Testes section
- Razor blades
- Seeds, oats, red and white beans, lima beans, sunflower
- Vaseline
- Vermiculite
- Wood box

LIVING AND FRESH MATERIALS

- Drosophilia media
- Drosophilia melanogaster (different genetic strains)
- Earthworms
- Eggs, chick (fertilized)
- Fish, living (guppies or others)
- Frogs, living (male and female)
- Frozen bull sperm (if available)
- Hydra (living)
- Liverworts, living
- Mold, bread and fruit
- Moss, living
- Paramecium culture
- Planaria culture
- Plants (freshly picked), such as raspberry, strawberry, mint, potato tuber, iris rhizome, tulip bulb, snapdragon flowers, sage flowers, daisies, asters, lily flowers
- Pond water
- Protococcus, living
- Spirogyra culture
- Sea urchins, living (male and female)
- Sea water, fresh
- Yeast culture

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

ESTIMATED TEACHING TIME: 5 WEEKS

Suggested allotment of time in block below:

Monday	Tuesday	Wednesday	Thursday	Friday	Week
Mitosis	Mitosis Meiosis	Asexual Reproduction	Asexual Reproduction	Optional	1
Sexual	Sexual	Embryology	Embryology	Embryology	2
Patterns in Heredity	Patterns in Heredity	Patterns in Heredity	Patterns in Heredity	Optional	3
Patterns in Heredity	Changes in Living Things	Changes in Living Things	Changes in Living Things	Optional	4
Changes in Living Things	Changes in Living Things	Changes in Living Things	Changes in Living Things	Optional	5

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

CONCEPTS TO CONSIDER

Mitosis is the regular division of a cell in which each of the two daughter cells receive exactly the same number and same kind of chromosomes that the parent cell had.

Each chromosome brings about a synthesis of an exact replica of itself immediately adjacent to it.

New chromosomes are manufactured from raw materials in the nucleus before visible mitosis begins.

Each mitotic division is a continuous process, with each stage merging into the next one.

The spindle fibers help to guide the replicates of chromosomes to the poles in an orderly fashion.

The centromere and spindle fiber are essential for movement of the chromosomes.

Chromosomes are aligned singly on the spindle during the metaphase in mitotic division.

Chromosomes are aligned on the spindle in tetrads during the metaphase of the first meiotic division and in dyads in the second meiotic division.

Constancy of chromosome number in cells of successive generations of living organisms is ensured by meiosis.

Meiosis is a process whereby the chromosome number is reduced to one half or monoploid.

Asexual reproduction is characterized by the presence of a single parent, one that splits, fragments, or produces spores so as to give rise to two or more offspring.

Offspring produced asexually have exactly the same inherited characteristics as the parent.

Many plants develop special structures for asexual reproduction, such as underground stems (rhizomes and tubers) and horizontal stems (runners).

Sexual reproduction is a fusion of two nuclei from different cells into one cell (zygote).

Gametes--eggs and sperm--have a monoploid number of chromosomes.

Many lower animal forms are hermaphroditic; both ovaries and testes are present in the same individual and it produces both eggs and sperms.

The development of an unfertilized egg into an adult animal is called parthenogenesis.

Among vertebrates, a wide assortment of accessory structures has evolved to aid the union of the sperm and eggs and to ensure the development of the embryo.

Few animals such as coelenterates have alternate sexual and asexual generations.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

Most animals reproduce by sexual means and have permanent sex organs.
The process by which any single fertilized egg develops into a many-celled embryo is called cleavage.
When the embryo consists of several hundred cells arranged in the form of a hollow ball (the wall consisting of a single layer of cells), it is called the blastula stage.
When the embryo begins to change from a single-layered hollow ball into a triple-layered stage, it is called gastrulation.
Two germ layers formed in the gastrula are the ectoderm (outer) and the endoderm (inner).
In all animals (except sponges and most coelenterates) a third germ layer develops between the outer and inner layer called the mesoderm.
After gastrulation the patterns of development of different animal groups differ widely according to the type of organism to be produced.
Ectoderm, mesoderm, and endoderm are referred to as primary germ layers.
The primary germ layers give rise to all the tissues and organs of a living animal.
The outfolding and fusion of the fold edges of ectoderm in the gastrula is the basis of the nervous system; it develops into a brain in the fore part and into the spinal cord in the hind part.
Most flowering plants can reproduce sexually and asexually.
The fertilized egg of a flowering plant, the ovule, grows into an embryo encased in a seed, and the ovary into the fruit.
The transfer of pollen from stamen to pistil in flowers is called pollination.

TEACHING APPROACH (Methods and Activities)

Discuss cell reproduction.

-Give an explanation of the process of mitosis, using the chalkboard or flannel board.
-Student teams prepare onion root tips to be used in viewing mitotic figures microscopically. See suggested laboratory activity on 346-47.
-Students examine prepared slides of whitefish blastula under the microscope to see mitotic figures. Sketches of observations are to be made for future reference.
-Using toothpicks, pipe cleaners, or construction paper cutouts, students visualize the replication of chromosomes during mitosis. See suggested laboratory activity on 348-49.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

Discuss meiosis

-Give an explanation of the process of meiosis, using the chalk board or flannel board.
-Students visualize the reduction division by using toothpicks, pipe cleaners, or construction paper cutouts to show the movement of chromosomes during meiosis. See suggested laboratory activity on p. 350-51.
-Students examine prepared slides of a section through testis or ovary of frog or other animal. Sketches of observations made under the microscope are placed in students' data book for future reference.
-Discuss the difference between mitosis and meiosis.
-Prepare a diagram of gametogenesis on the bulletin board or chalk board and give an explanation of the function of meiosis during gametogenesis.
-Encourage some students to make three-dimensional models of mitosis and meiosis to be used in class demonstrations.

Discuss asexual reproduction

-Students observe Protococcus (Pleurococcus) under the microscope. Locate plants that are in the process of reproducing. Students make sketches of the plant dividing.
-Discuss binary fission, using a chalk-talk or flannel board demonstration.
-Students make observations of various fresh-water algae showing binary fission. Students make sketches of their microscopic observations for their data books.
-Students make observations of yeast, bread mold, and other fungi showing asexual reproduction. See suggested laboratory activity on p. 353-54.
-Display gemmae of liverworts. Student teams observe gemmae with tripod lenses and make sketches of their observations.
-Students make observations of prepared slides of hydra budding and Paramecium going through binary fission.
-Whenever possible students should make observations of hydra and Paramecium under the microscope, using living mounts. See suggested laboratory activity on p. 353-54.
-Discuss regeneration in planaria and earthworms. Students do regeneration experiments, as suggested on p. 357-358, p. 359.
-Display starfish specimens that show regeneration of arms. (Dried specimens.)
-Place a chart on the chalk board which will help to summarize the various types of asexual reproduction studied and observed in the laboratory classroom.
-Discuss asexual reproduction in higher seed plants.
-Make a display of iris rhizome, tulip or onion bulb, gladiolus corm, potato tuber to illustrate specialized structures for asexual reproduction.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

-Assign students to bring in English ivy, carrot tops and Bryophyllum leaves for experiments suggested on p. 355.
-Assign an interested student to demonstrate various types of grafting in plants.
-Encourage a student team to devise experiments to show the value of grafting.

Discuss sexual reproduction.

-Students prepare slides showing spirogyra in conjugation. If living cultures are not available, use prepared slides. Students examine slides under the microscope and make sketches of their observations.
-Discuss briefly sexual reproduction in the algae, Ulothrix.
-Students prepare slides showing Paramecia in conjugation. If this culture is not available, students should make observations of prepared slides under the microscope. Students make sketches of their observations.
-Discuss conjugation in plants and animals.
-Discuss sexual reproduction in higher seed plants. Students make observations of pollen grains under the microscope as suggested on 362-363.
-Prepare materials to show growth of pollen tubes in the classroom laboratory. See activity on p.362-63.
-Assign students to bring in a variety of flowers for pollen experiment.
-Encourage several students to make collections of living sea urchins for experiments in fertilization or order living sea urchins from the Science Center.
-Student teams obtain eggs and sperm of sea urchins, as suggested on pp.364-365.
-Demonstrate how to prepare vaseline-mounted slides so that the fertilized eggs may continue to develop for several days and continued observation may be made under the microscope.
-Students make observations of fertilized sea urchin eggs to watch cleavage. Students make sketches of their observations.
-Encourage several students to make collections of frog eggs in early spring for classroom observation. Students observe frog eggs under the microscope or tripod lens and make sketches of stages of cleavage and embryology.
-Students may make observations of sperm cells under the microscope, as suggested on p. 367.
-Interested students may be encouraged to induce frogs to produce eggs out of season and bring about artificial fertilization. See activity suggested on p. 368.

-Encourage students interested in tropical fish to set up an aquarium and observe reproduction in live-bearing fish. See activity suggested on p. 369.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

Discuss embryology, differentiation of tissue, and growth patterns.

- Discuss the embryology of a chick. Students make observations of fertilized chick eggs incubated three days and five days and make comparisons of development taking place. See suggested activity on p. 370.
- Obtain prepared slides of the early stages of chick embryology. Students observe slides under microscope and make sketches of their observations.
- Make comparisons of the development of frog, chick, and mammal. This is a good activity for the flannel board or the bulletin board. Assign student teams to prepare cutouts for each animal's development.
- Discuss differentiation of tissue in the embryo, such as ectoderm, endoderm, and mesoderm.

DEPTH PROBE

- MITOSIS, pp. 346-347 (Average Student Basic Activity)--To learn and understand the concept of cell reproduction. Students work individually or in pairs.

- MITOSIS MODEL, pp. 348-349 (Slow Learner Student Basic Activity)--To illustrate the mechanism of mitosis (cell division). Students work in pairs or individually.

- MEIOSIS, pp. 350-352 (Average Student Basic Activity)--To understand and learn the mechanism of reduction division in reproductive cells. Students work in pairs or individually.

- ASEXUAL REPRODUCTION, pp. 353-354 (Average Student Basic Activity)--To learn about the various forms of asexual reproduction and to understand that all living things arise from pre-existing living things. Students work in pairs or in teams.

- ASEXUAL REPRODUCTION IN HIGHER SEED PLANTS, pp. 355-356 (Average Student Basic Activity)--To learn the various types of asexual reproduction carried on by seed plants. Students work in pairs or in teams.

- REGENERATION, pp. 357-358 (Average Student Basic Activity)--To determine how planaria regenerate when cut into pieces of various shapes. Students work in pairs or in teams.

- REGENERATION IN EARTHWORMS, p. 359 (Average Student Basic Activity--Optional)--To determine how earthworms regenerate when cut into pieces of various shapes. Students work in pairs or in teams.

- CONJUGATION IN SPIROGYRA, p. 360 (Average Student Basic Activity--Optional)--To induce conjugation in Spirogyra in the laboratory classroom for student observation. Students work in pairs or in teams.

- LIFE CYCLE OF THE MOSS, p. 361 (Average Student Basic Activity--Optional)--Growing the moss spores on culture media in the classroom laboratory for student observation. Students work in pairs or teams.
- POLLEN GRAINS, pp. 362-363 (Average Student Basic Activity)--To learn how flowering plants reproduce sexually and the function of the pollen in this process. Students work in pairs or in teams.
- FERTILIZATION AND DEVELOPMENT OF SEA URCHIN EGGS, pp. 364-365 (Average Student Basic Activity--Optional)--To help in understanding the process of fertilization and the development of the zygote. Students work in pairs or in teams.
- DEVELOPMENT OF A FROG EGG, p. 366 (Average Student Basic Activity--Optional)--To observe the development of a frog egg in the classroom laboratory. Students work in teams.
- OBSERVING SPERM CELLS, p. 367 (Average Student Basic Activity--Optional)--To observe the shape and size of the male gamete. Students work in pairs or in teams.
- ARTIFICIAL INDUCEMENT OF FROGS' EGGS, p. 368 (More Able Student Basic Activity--Optional)--To supply living frog eggs out of season for the observation of fertilization and cleavage in the laboratory classroom. Students work in pairs or teams.
- REPRODUCTION OF FISH IN AN AQUARIUM, p. 369 (Average Student Basic Activity--Optional)--To make observations of sexual reproduction in a classroom aquarium, using live-bearing fish. Students work in teams.
- STUDYING THE CHICK EMBRYO, pp. 370-372 (Average Student Basic Activity)--Comparing fertilized eggs of three to five days of incubation with an unincubated fertilized egg; to study advances that have taken place in the development of a chick embryo. Students work in pairs.
- HOMEMADE INCUBATOR, p. 373 (More Able Student Basic Activity--Optional)--To build a working incubator for home or classroom use in the study of chick embryology. Students work individually or in pairs.
- CYTOCHROME OXIDASE IN THE CHICK EMBRYO, p. 374 (More Able Student Basic Activity--Optional)--Comparing the amount of cytochrome oxidase in chick embryo tissues from three to five days old. Students work in pairs or in teams.

"TOOLS" FOR EXTENDING CONCEPTS

- Assign a student to report on August Weismann and the continuity of germ plasm theory.
- Prepare a bulletin board entitled ASEXUAL AND SEXUAL REPRODUCTION.
- Encourage some students to dissect a fish, such as perch or mackerel, and locate the ovary or testes. Students make sketches of the organs of a fish.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

"TOOLS" FOR EXTENDING CONCEPTS

- -Encourage several students to bring in grunion eggs (in season). This demonstration is a fascinating one to watch, for the hatching time can be made to occur during the classroom period. Carefully place grunion eggs in a small finger bowl. Cover with sea water and sand. Shake vigorously until hatching takes place.
- -Obtain the reproductive organs of a female chicken. Students make observations and sketches. Discuss reproduction in birds. Discuss some interesting and unique nesting habits of birds.
- -Encourage a student to breed a pair of hamsters, white rats, or guinea pigs. Students may keep a record of their observations of the pregnancy, birth, and care of the young.
- -If possible, secure embryos of pigs (or other animals) with all of the embryonic membranes intact. It will be an exciting dissection for class demonstration.
- -Prepare a bulletin board entitled REPRODUCTIVE STRUCTURES OF FLOWERS.
- -Encourage a student to prepare a three-dimensional model of a typical flower, showing pollination and fertilization.
- -Assign several students to prepare three-dimensional models of cleavage of various types of fertilized eggs.
- -Assign a student team to study human embryology. Team prepares a bulletin board or flannel board demonstration of the key stages of the process for the entire class.
- -Prepare a bulletin board entitled GERM LAYERS to show differentiation of tissue.
- -Plan to show films such as "Mitosis" EBF
  - "Reproduction Among Mammals" Fsd 613.9-1
  - "Monarch Butterfly Story" Fsd 595.78-7
  - "Flowers at Work" Fsd 582.13-2
  - "Basic Nature of Sexual Reproduction" Fsd 574.1-3
  - "Fish Out of Water" Fsd 597.5-1
  - "Reproduction in Animals" Fsd 591.16-2
  - "Reproduction in Plants" Fsd 581.16-1
  - "Development of the Chick Embryo" Fsd 591.33-1
- -Plan to show filmstrips such as:
  - "Reproduction Among Mammals" Set 1, S-51
- -Plan to borrow exhibits such as:
  - "Tomato Sphinx Moth" Set 1
  - "Monarch Butterfly" Set 1

Many other exhibits are suggested on p. 139-142 of Catalog of Audio-Visual Materials, Secondary Grades, Los Angeles City Schools, Division of Instructional Services, Audio-Visual Section. Publication 579, 1961.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

PLANNING AHEAD

-Locate and store about 100 baby food jars or ½ pint milk jars.
-Assign some interested students to help in the preparation of cotton plugs for culture jars.
-Order Drosophila Culture Media from Science Center. Each package supplies enough to prepare 20½ bottles of culture. In addition, order several strains of Drosophila.
-Locate and reserve about 18 or twenty camel's hair brushes.
-Encourage several interested students to prepare re-etherizers for the entire class. See p. 387 for instructions.
-Prepare a bulletin board display showing the various mutations to be used in Drosophila crosses.
-Prepare cutouts of DNA and RNA for flannel board lesson on structure of these molecules.
-Encourage some student to make a three-dimensional model of the DNA molecule. See excellent reference on model making of a DNA molecule, Life's Key: DNA by Carleen Maley Hutchins. Publishers - Coward-McCann Inc., New York, 1961. There should be a copy of this book in the school library.
-Obtain enough pipe cleaners (white in color) to do the experiment given on pp. 348 and 384.
-Locate and store test tubes, HCL, and Ammonium Hydroxide. See p. 384 for exact dilutions.
-Obtain a large bag of white bush beans and one of red bush beans. Encourage students to bring small sandwich bags to school for bean probability experiment.
-Make arrangements with a hospital or dentist friend to irradiate seeds for experiment on p. 418.
-Locate and store paper cups or seed flats, vermiculite (or sawdust) and other materials for experiment on p. 418.
-Order P.T.C. Taste papers (Consummable Supply) - American Genetics Association, Washington, D. C.
-Reserve books in the library, such as New You and Heredity, Amram Scheinfeld, Genetics is Easy, Philip Goldstein. See suggested reference list on p. 382.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

BROADENING "CONTENT HORIZONS"

Teacher References:

Articles from Scientific American

-Tyler, Albert. "Fertilization and Antibodies," (June, 1954)
-Waddington, C. H. "How Do Cells Differentiate?" (Sept., 1953)
-Mazia, Daniel. "Cell Division," (August, 1953)
-Puck, Theodore. "Single Human Cells in Vitro," (August, 1957)
-Williams, Carroll. "The Metamorphosis of Insects," (April, 1950)
-Ebert, James. "The First Heartbeat," (March, 1959)
-Wigglesworth, V. B. "Metamorphosis and Differentiation," (Feb., 1959)
-Mazia, Daniel. "How Cells Divide," (Sept., 1961)
-Fischberg, Michail and A. Blackler. "How Cells Specialize," (Sept., 1961)
-Gray, George. "The Organizer," (Nov., 1957)
-Singer, Marcus. "The Regeneration of Body Parts," (Oct.,1958)
-Koller, Dov. "Germination," (April, 1959)

Patten, B. M. Human Embryology, 2nd Ed. New York: Blakiston Co., 1953.

McElroy, W. D. and B. Glass (Eds.) The Chemical Basis of Development. Baltimore: Johns Hopkins Press, 1958.

Rugh, Roberts. Experimental Embryology. Ann Arbor: Edwards, 1948.

Waddington, C. H. How Animals Develop. London: Norton, 1936.

Sussman, Maurice. Animal Growth and Development. Englewood Cliffs, N.J.: Prentice-Hall, 1960.

Wilson, E. B. The Cell in Development and Heredity. 3rd Ed. New York: Macmillan, 1947.

Huettner, A. F. Fundamentals of Comparative Embryology of the Vertebrates. Revised Ed. New York: Macmillan Co., 1949.

Barth, L. G. Embryology, Revised Ed. New York: Dryden Press, 1953.

Berrill, L. Growth, Development, and Pattern. San Francisco: Freeman, 1961.

Bonner, J. T. Morphogenesis. Princeton, N. J.: Princeton University Press, 1952.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

Berrill, N. F. *Sex and the Nature of Things*. New York: Dodd, Mead, 1953.

Corner, G. W. *Ourselves Unborn*. New Haven, Conn.: Yale University Press, 1944.

Milne, Lorus and Margery. *The Mating Instinct*. Boston: Little, Brown, 1954.

Student References:

Gabriel, M. L. and S. Fogel. *Great Experiments in Biology* Section on Embryonic Differentiation. Englewood Cliffs, N. J.: Prentice-Hall, 1955.

Waddington, C. H. *Principles of Embryology*. London: G. Allen, 1956.

Schrader, F. *Mitosis*. New York: Columbia University Press, 1952.

Pool, R. J. *Flowers and Flowering Plants*, 2nd Ed. New York: McGraw-Hill,1950.

Simpson, G. et al. *Life: An Introduction to Biology*. New York: Harcourt, Brace, and World, 1957. (Title III Collection)

Textbook References:

Smith, Ella Thea. *Exploring Biology*. pp. 486-513.

Moon, Mann and Otto. *Modern Biology*. Spread throughout pp. 219-414.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

MITOSIS

PURPOSE

To learn and understand the concept of cell reproduction.

ACTIVITY MATERIALS

Prepared slides of mitosis in Ascaris or Whitefish blastula
Prepared slides of onion root tip
Aceto-carmine stain
Slides and cover slips
Microscope
Onion roots (living)

WHAT TO DO

Place an onion bulb partially in water so that the roots will grow freely. (See Figure 1.) Cut the root tips when they are about 1 cm in length. Make cuttings of root tips during various hours of the day. Make some cuttings during the early morning, afternoon, and late afternoon. Determine the time of day when mitotic divisions occur most frequently.

Prepare a saturated water solution of paradichlorobenzene. Soak the root tips in this solution for about three hours in a cool room. Prepare a mixture of 2% aceto-orcein solution, and one part of 1 N HCL. Place this mixture with the root tip cuttings into a test tube and heat them for a short time until they just reach the boiling point. Pour them into a dish and allow them to cool for about five minutes. Transfer the root tips to a drop of 1% aceto-orcein solution on a clean slide.

ALTERNATE METHOD

Slice the root tip into a small pyrex watch glass. The watch glass should contain aceto-carmine stain. To prepare the stain, mix 45 ml glacial acetic acid with 55 ml of distilled water. Heat the mixture to a boiling point. Add powdered carmine to the hot mixture until the solution of carmine becomes super-saturated. Cool and filter. Add one or two drops of 4% iron alum. Heat the root tips in this stain over a moderate flame for several minutes. Do not boil. Remove the root tips from the stain and mince about .2 cm of the root tip, on the slide, with a steel blade.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

Make observations of stained root tip under low power and high power of microscope. Make sketches of as many different stages of mitosis as you can. Describe the various stages; explain how they differ from one another. Do all the cells show mitotic figures? What part of the cell is darkly stained? Compare your slide with your neighbor's and also with a commercially prepared slide. Does your partner's slide show the same mitotic figures?

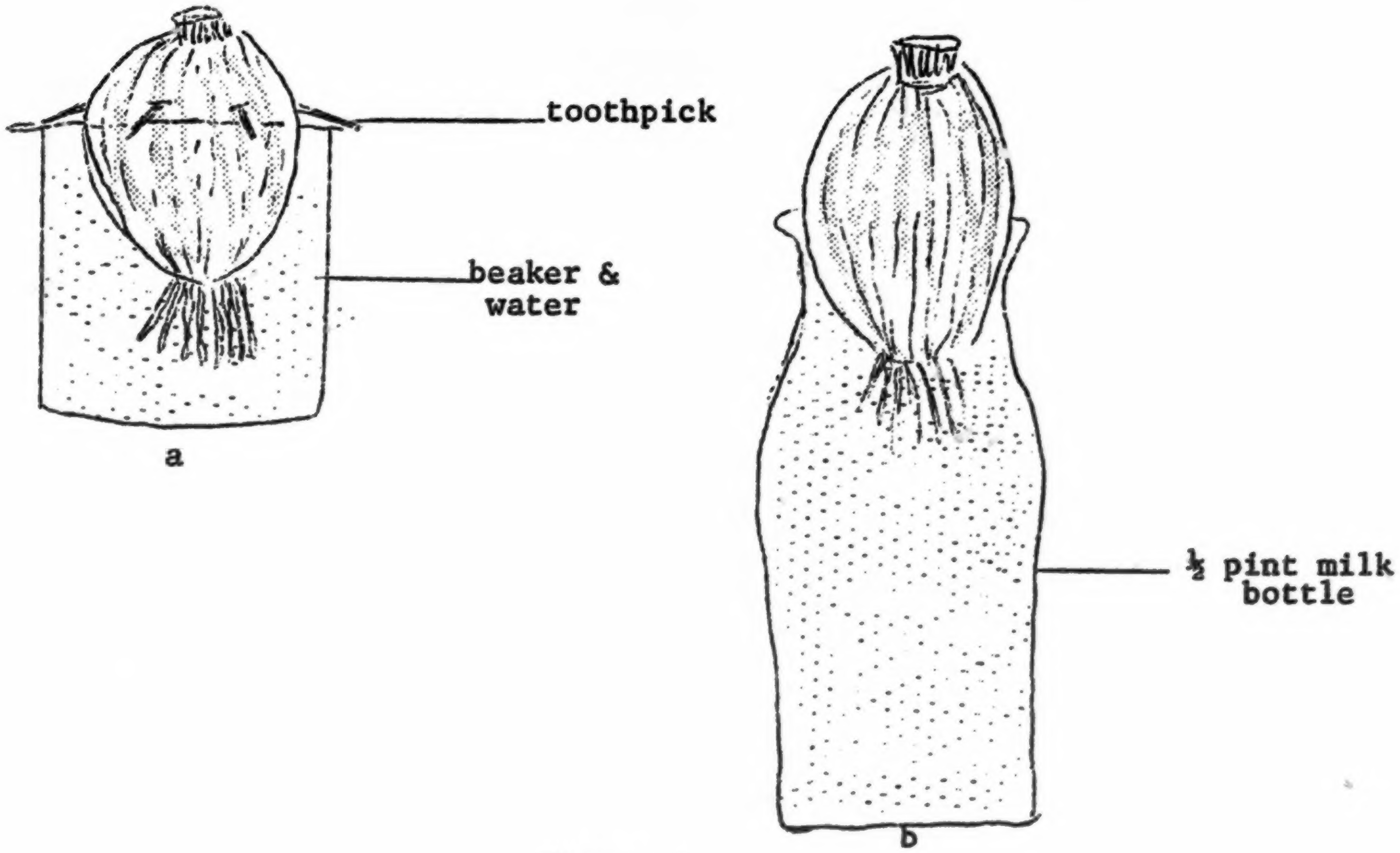


Figure 1

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

MITOSIS MODEL

PURPOSE

To illustrate the mechanism of mitosis or cell division.

ACTIVITY MATERIALS

Pipe Cleaners
Wood or plastic beads with a hole large
enough to accommodate two pipe cleaners

WHAT TO DO

Give each student a sheet of brown wrapping paper or black pattern paper. Student draws a spindle on the paper (with chalk or crayola) large enough so that six chromosomes (pipe cleaners and beads) may be arranged on its equator.

Prepare three pairs of chromosomes using pipe cleaners and large wood beads. (Figure 1) Chromosome models vary in shape and also in placement of wood bead.

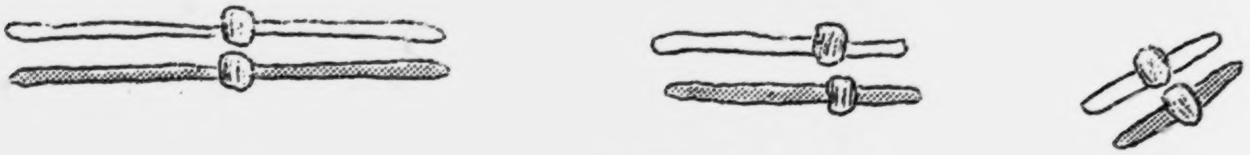


Figure 1

To represent the replication of the chromosomes and formation of the chromatids, take two pipe cleaners of identical color and length and place them through the same wood bead. As in figure 2. Arrange the six chromosomes on the equator of the spindle (figure 3). At this stage the centromere (large wood bead) replicates. Represent this replication by undoing the chromatids (two pipe cleaners enclosed by one wood bead) from the same centromere and provide a separate centromere for each chromatid. Move each chromatid toward a pole of the spindle.

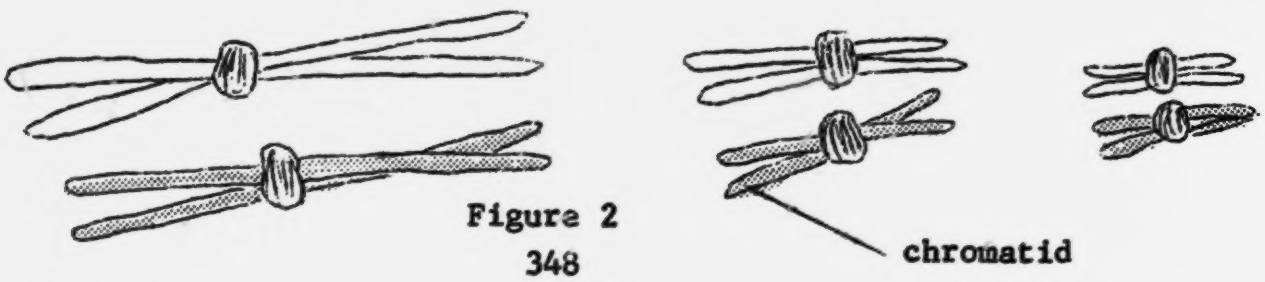


Figure 2

1

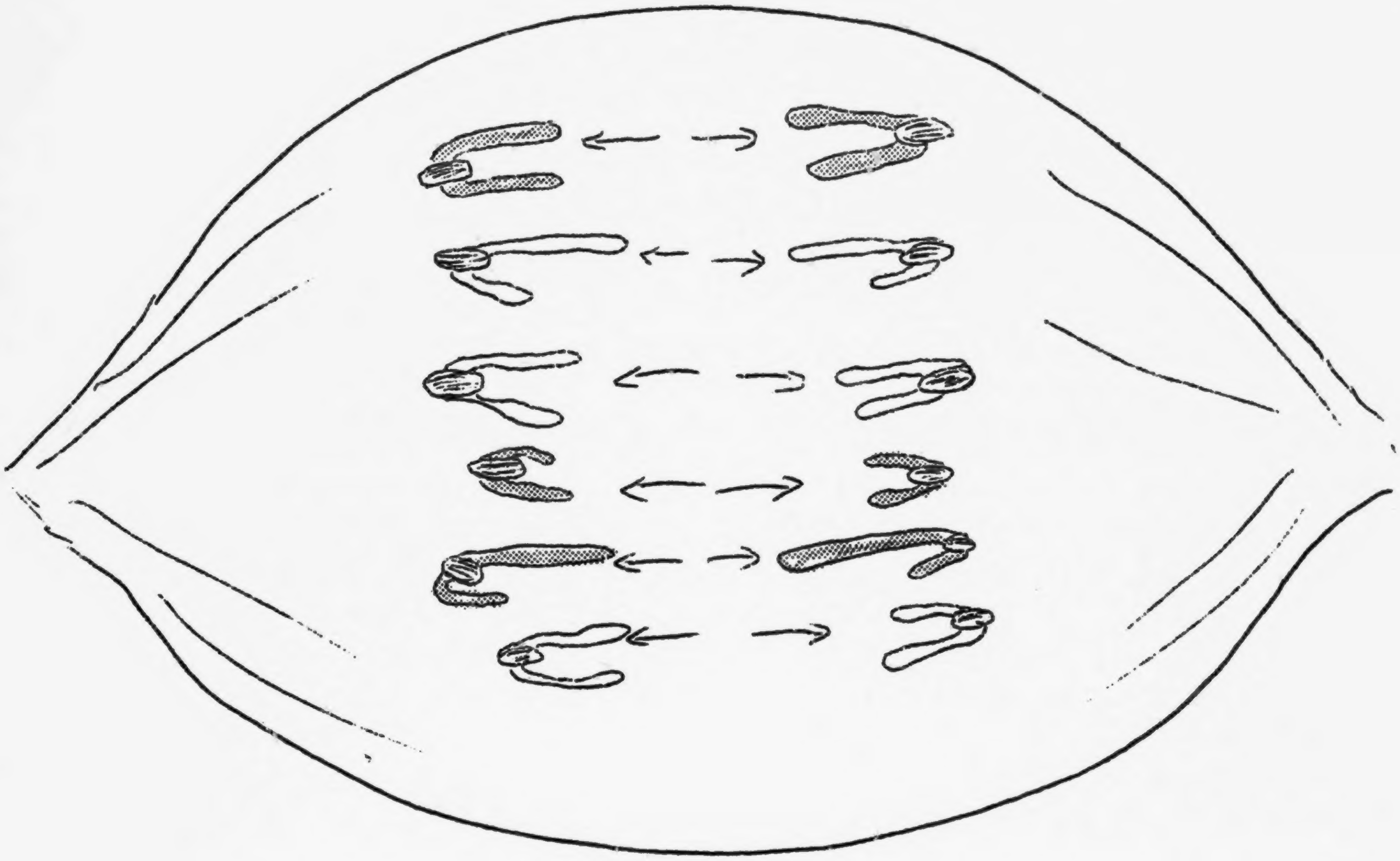


Figure 3

How many chromosomes are there at each pole? How many chromosomes were there in the original cell? How does the process of mitosis enable the new cells formed to maintain the constant number of chromosomes? (What is the function of the centromere? Why are the chromosomes aligned in the center of the spindle? Of what purpose are the spindle fibers in the process of mitosis? What is a chromatid?

Adapted from High School Biology, Green Version - The Laboratory, Part Two, Exercise 11.7, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

MEIOSIS

PURPOSE

To understand and learn the mechanism of reduction division in reproductive cells.

ACTIVITY MATERIALS

Poppit beads of several colors
Metal tape or floral wire
Wrapping paper or black pattern paper

WHAT TO DO

Prepare twelve strands of poppit beads, four of each length; two of one color and two of another color. See figure 1

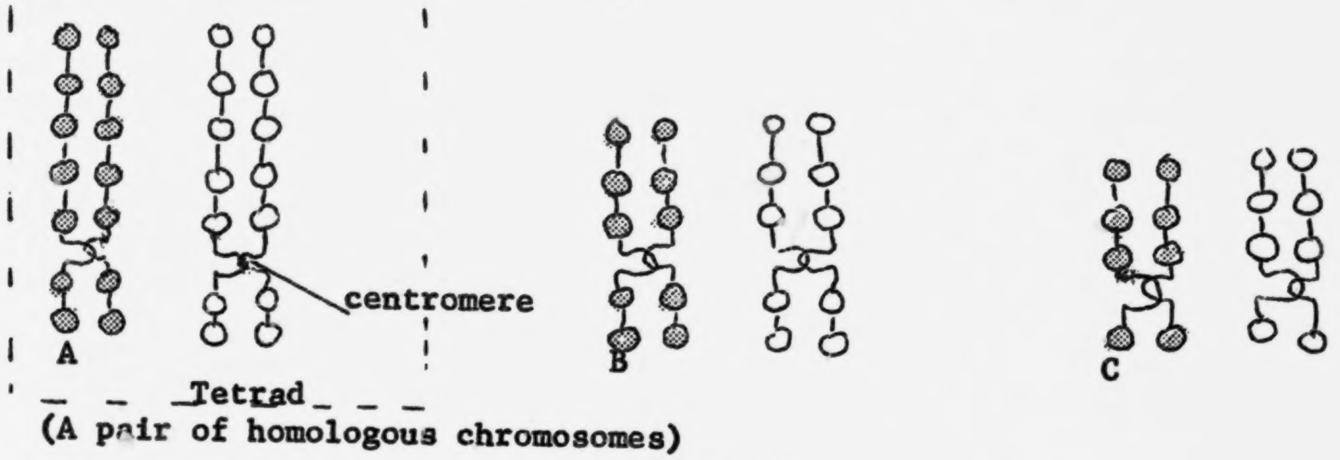
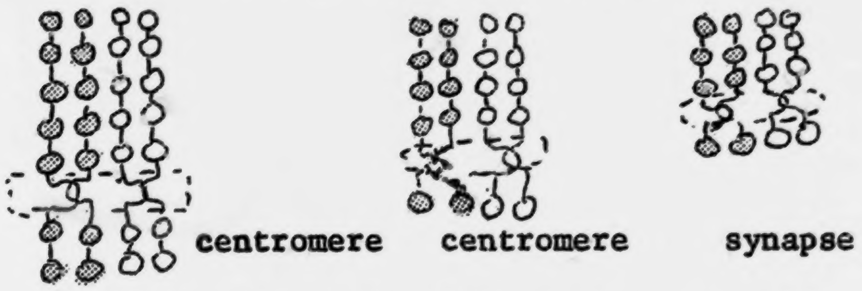


Figure 1

Fasten two strands of poppit beads of the same color and length together with floral wire to represent chromatids of a single chromosome. Fasten two strands of the other color and same length as the first group with floral wire to represent chromatids of a single chromosome. You should now have a pair of homologous chromosomes (a pair) in the tetrad stage (four chromatids). See figure 1-A. Do the same for each of the remaining strands of poppit beads. See figure 1 - B and C. These represent three pairs of homologous chromosomes in a cell.

Synapse the homologous chromosomes by fastening their centromeres together with another twist of floral wire. You should now have four chromatids (tetrad stage) in each of three groups. See Figure 2.


centromere
centromere
synapse

A tetrad (a pair of homologous chromosomes)

Figure 2

To represent crossing over, break apart two chromatids belonging to synapsed homologous chromosomes at the same level in each one, and reattach the end pieces to the opposite chromatid. Fasten a piece of floral tape or wire around the two chromatids at their point of exchange. This represents the Chiasma (Greek word for cross) that holds the real chromosomes together for a time when they cross over. See Figure 3.

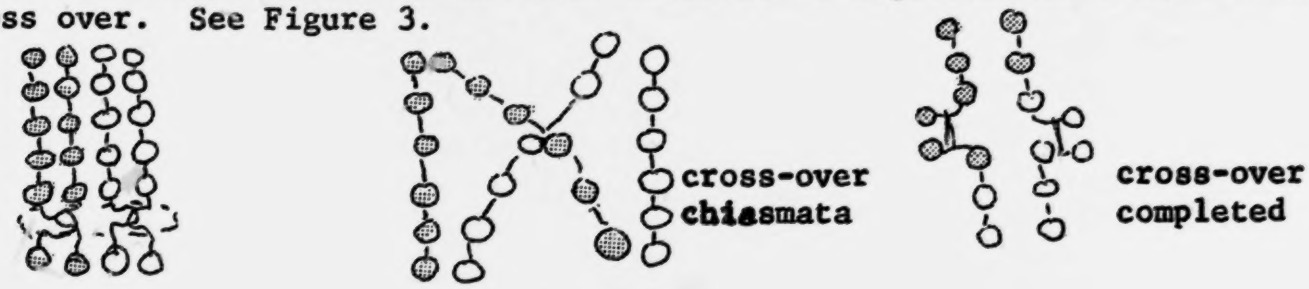

cross-over
chiasmata
cross-over
completed

Figure 3

Draw a spindle on the surface of a piece of black pattern paper or wrapping paper with chalk or crayola. Place the three tetrads across the equator. Now separate the tetrads so that a chromosome of each will be moved to an opposite pole.

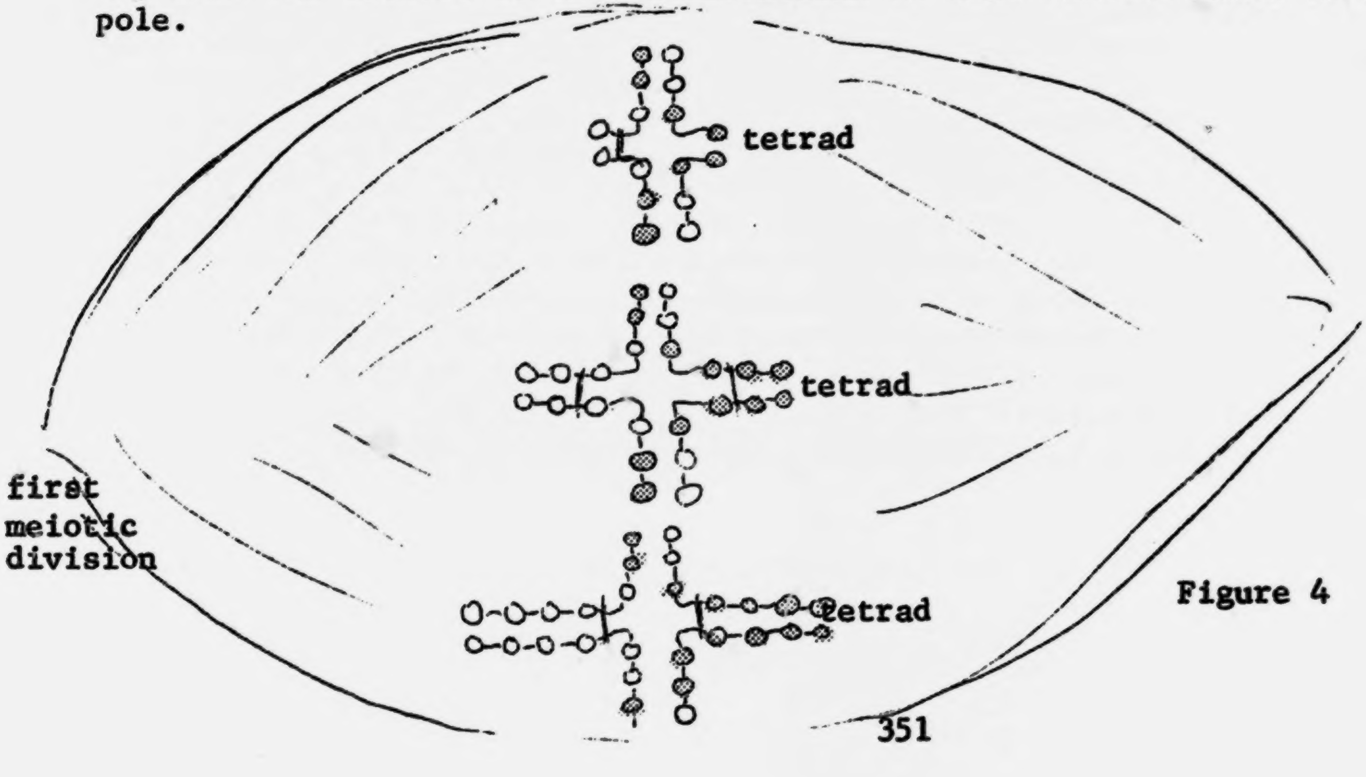
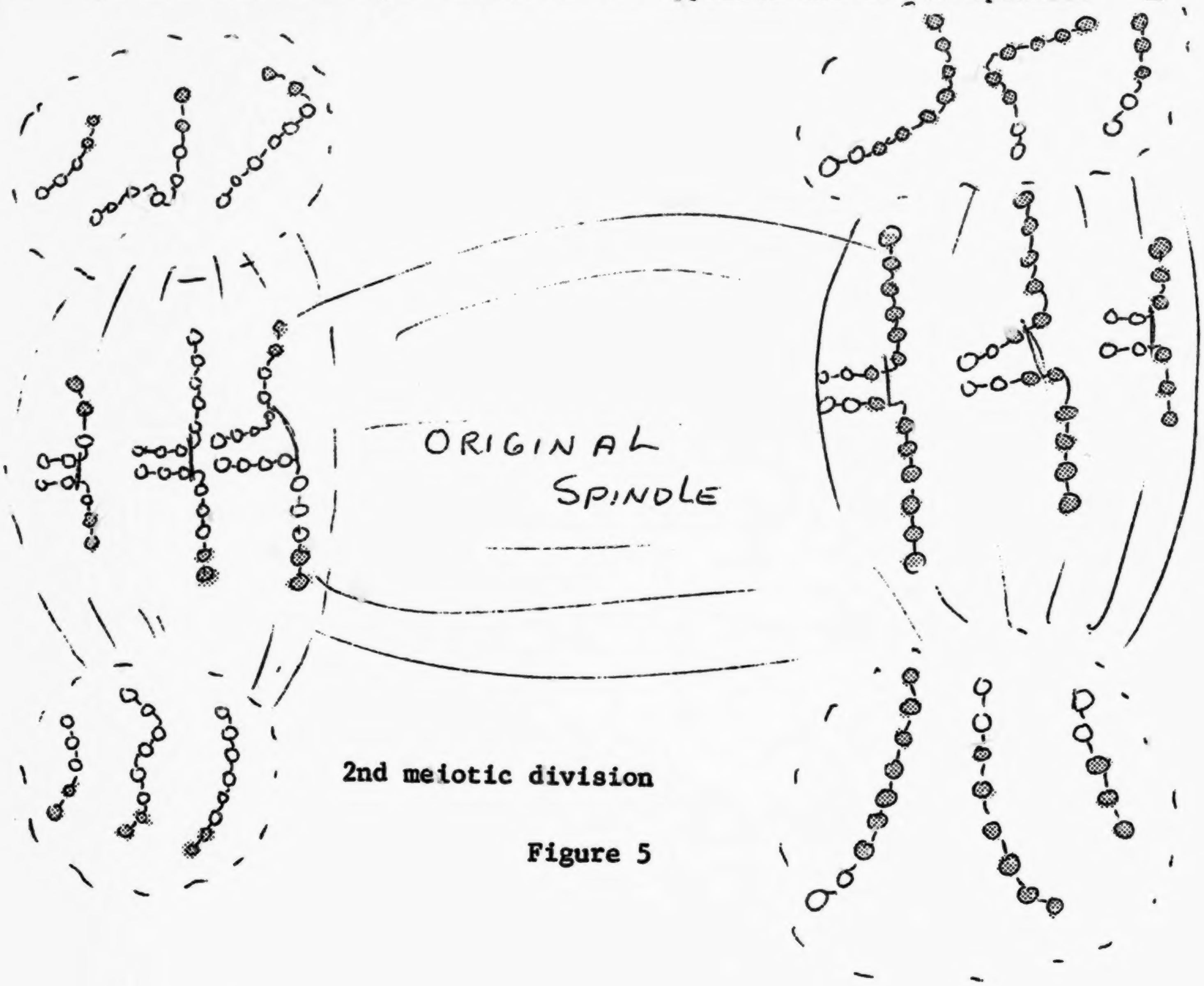

tetrad
tetrad
tetrad
first
meiotic
division

Figure 4

Now draw two smaller spindles at right angles to the large spindle and centered around the two clusters of chromosomes at the poles of the original spindle. Figure 5. Unfasten the floral wire holding the chromatids together (centromeres) pull the chromatids apart to the opposite ends of the secondary spindles. Do this for each of the three chromosomes in each group. You should now have four chromosomes, each a single strand at the opposite end of the spindle.



2nd meiotic division

Figure 5

How many chromosomes are there at each new daughter cell? Do the chromosomes replicate themselves in the first meiotic division? Do the chromosomes replicate themselves in the second meiotic division? What is meant by synapse? What happens when crossing-over takes place? Of what importance is crossing-over? What is the single major difference between meiosis and mitosis?

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

ASEXUAL REPRODUCTION

PURPOSE

To learn about the various forms of asexual reproduction and to understand that all living things arise from pre-existing living things.

ACTIVITY MATERIALS

Yeast culture
Paramecia culture
Hydra
Bread mold

Liverworts
Protococcus
Bacteria
Prepared slides of
  Hydra budding
  Yeast budding
  Paramecium binary fission

Slides and cover slips
Microscope
Pipette
Beakers

WHAT TO DO

Binary Fission:

Examine a prepared slide of Paramecium undergoing binary fission under low power of the microscope. If a culture of Paramecia is available prepare a wet mount and observe under low power. Search the slide carefully for any animals undergoing binary fission. Make a sketch of a Paramecium dividing into two. What kind of reproduction is this?

Prepare a slide of living Protococcus. Are there any cells undergoing division. Make a sketch of these cells showing division. What kind of reproduction is this?

Budding:

Prepare a slide of yeast culture that has been growing for several hours. Observe under low power and then high power. Make a sketch of several reproducing yeast cells. What is the difference in this type of reproduction? How many cells arise from a single parent?

Examine a prepared slide showing Hydra budding. Make a sketch of this under low power. What kind of reproduction is this? Does the animal divide into two equal parts?

Spore:

Prepare a slide showing bread mold. Make observations of bread mold under low power and high power. Press cover slip against slide squashing the bread mold sporangia. Make observations of cells from the sporangium. What kind of reproduction is this? Are each of the cells capable of producing a new organism?

Fill in information from microscopic observations and other references:

Living Org.	Form of Asexual Reproduction
Paramecium	
Yeast	
Bacteria	
Bread mold	
Hydra	
Others	

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

ASEXUAL REPRODUCTION IN HIGHER SEED PLANTS

PURPOSE

To learn the various types of asexual reproduction carried on by seed plants.

ACTIVITY MATERIALS

Slips from plants such as avocado, peach, rose, tomato, pelargonium
Paraffin or grafting wax
String
Knife

Plants such as raspberry or strawberry
Plants such as peppermint
Plants such as potato or sweet potato
Plants such as gladiolus
Plants such as tulip, iris

WHAT TO DO

Observe strawberry or raspberry plants. Notice the stem portion that is horizontal to other stems of the plant. What is this called? What type of structure is produced at the nodes of the horizontal stem?

Observe the "root-like" structure of an iris plant. Examine this structure closely? Are there any buds located at the nodes? What will this structure form? What kind of reproduction is illustrated by this?

Examine a white potato. Where are the buds located? Why are potatoes cut into small pieces by the farmer for planting purposes? Cut a potato into several pieces being sure that each piece has at least one bud located in it. Plant these pieces in a seed flat. Make observations for several weeks. Water the plants every day.

Examine a bulb and corm from onion (or tulip) and gladiolus Cut the onion lengthwise. Notice the small stem at the base. What are the thickened structures around this? Where is the bud located? Where are the roots located? What kind of reproduction is carried on by the onion bulb? Examine a gladiolus corm. What are the general differences between a bulb and corm? Look for buds on the corm. Where are they located?

Illustrate a form of asexual reproduction by demonstrating various methods of grafting.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

Pick four or five leaves from Bryophyllum and plant them in damp sand so that the petiole and bottom third of the leaf are covered. Make observations every week and record information in data book.

Cut the stem of English Ivy into three or four inch segments that include two or three leaves. Use six paper cups filled with water. Cover each cup with aluminum foil and place each segment of ivy through the foil into the water. Make observations every week. Record information in data book.

Cut the top half-an-inch from six carrot roots. Put the cut surface down in the wet sand leaving the top exposed.

Be sure that all plants are kept moist. Water or check moisture every day.

SIDE GRAFT (Fig. 1). With a sharp knife, cut the scion into a wedge shape. Split the side of the stock as shown in diagram and insert scion in split section of the stock. Wrap the parts together tightly with string and cover with paraffin.

TONGUE GRAFT (Fig. 2). Make a tongue cut on the stock and a similar one on the scion. Join the two and tie tightly with string. Cover with paraffin.

CLEFT GRAFTING (Fig. 3). Select one of the large pieces of apple or pear stems as the stock. With a sharp knife, split one end as indicated in diagram. Select 2 twigs with buds as the scions, cut the stems into a wedge shape and insert in the split cleft of the stock so that the cambium layers of the stock and scion are in contact. Wrap tightly with string and cover with paraffin.

BUDDING (Fig. 4). Select the bud from a plant and remove as suggested by diagram. With a sharp knife, make a T-shaped cut in the stock. Insert the bud into the T-shaped cut. Wrap tightly together with string and cover with paraffin.

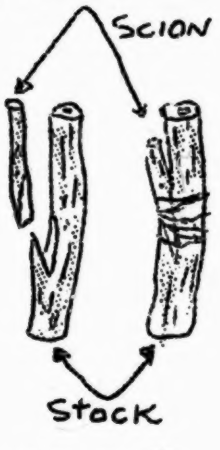


FIGURE 1

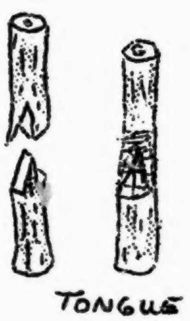


FIGURE 2

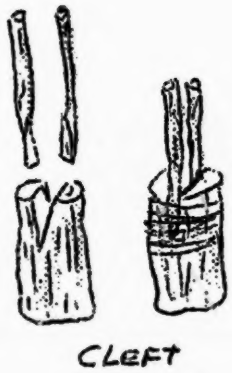


FIGURE 3

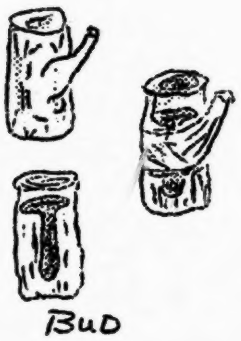


FIGURE 4

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

REGENERATION

PURPOSE

To determine how planaria regenerate when cut into pieces of various shapes.

ACTIVITY MATERIALS

Planaria
Razor blade or fine sharp scalpel
Microscope slides and cover slips
Small camel hair brush
Small glass dishes (syracuse dishes or petri dishes)
Spring water or pond water (or dechlorinated tap water).

WHAT TO DO

Obtain living planaria from Science Center on fresh materials order. Planaria may also be collected from slow-moving streams or ponds. Place several pieces of beef liver near the water margin of a stream or pond. Allow the meat to remain in the water for a period of 15 minutes to an hour. When the animals have attached themselves to the meat, collect piece of meat. Shake animals from the meat into a jar containing some of the pond water. Place planaria in an enamel pan or a granite pan half filled with pond water (or use dechlorinated tap water). Place a sheet of aluminum foil over the pan. Feed planaria small pieces of liver every four or five days. After each feeding, be sure to change water and remove all uneaten food.

Student teams will make experimental cuts as follows:

Prepare two small petri dishes or syracuse dishes with spring or pond water.

Mark one dish for anterior piece and the other dish for the posterior pieces.

Place a drop of pond water on a glass slide and transfer a planarian onto the slide by using a camel hair brush. After the animal has relaxed, cut the body quickly with a sharp razor blade or fine scalpel at point "a" in figure 1.

Place the anterior piece in dish marked for it and the posterior piece in the dish marked for it. Cover dishes and keep in dark, cool place.

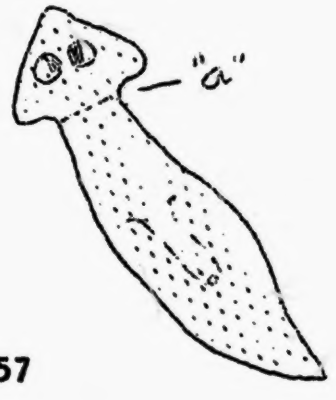
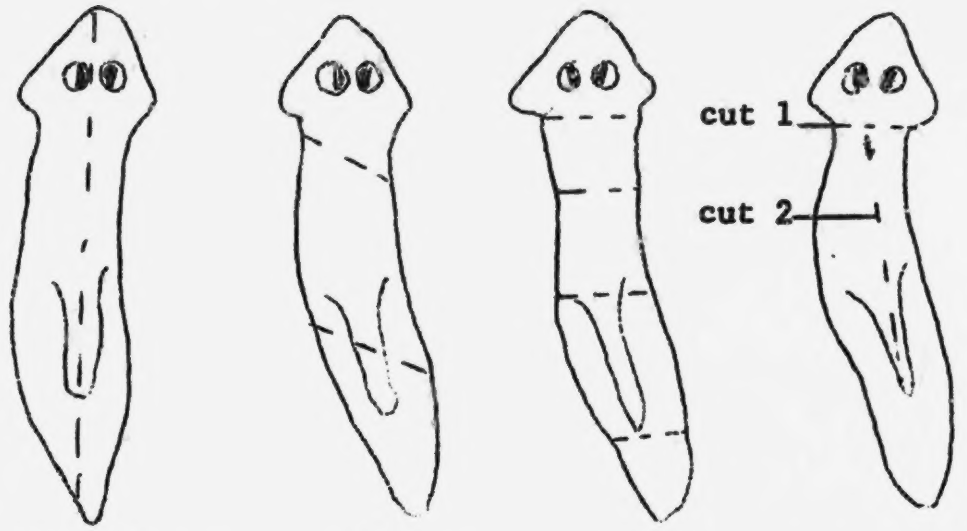


Figure 1

Examine the pieces every other day and make sketches of your observation. Be sure that all specimens are covered with spring or pond water. Do not allow any cut specimens to become dry. Use the microscope and make observations on how long it takes for a new bud to appear. How does the bud differ from the rest of the piece? What is the first differentiated structure to appear? Does the final animal look like a planarian?

Make the following cuts as illustrated in figure 2. Place all cut pieces into marked dishes and store in cool, dark place. Make observations every other day. Make sketches of your observations. Be sure all specimens are covered at all times with spring or pond water.



Remove head at cut 1. Then make cut 2 from top of head to a point just back of the mouth. Prevent halves from fusing by recutting in a twenty-four hour period.

Longitudinal cut **Diagonal cuts** **Short transverse cuts**

Figure 2

References of great use are:

Buchsbaum, Ralph. Animals Without Backbones. Chicago, Ill.: University of Chicago, 1948, pp. 124-131.

High School Biology, Green Version - The Laboratory, Part Three, Exercise 14.1, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

REGENERATION IN EARTHWORMS*

PURPOSE

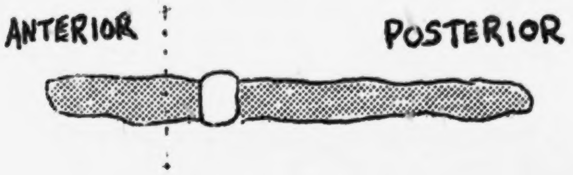
To determine how earthworms regenerate when cut into pieces of various shapes.

ACTIVITY MATERIALS

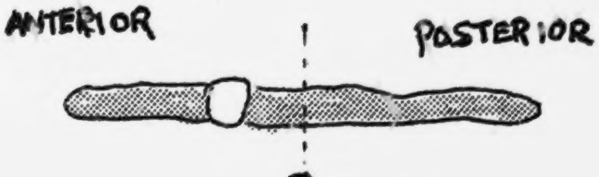
Razor blade
Earthworms
Several cans or flower pots
Humus and/or topsoil

WHAT TO DO

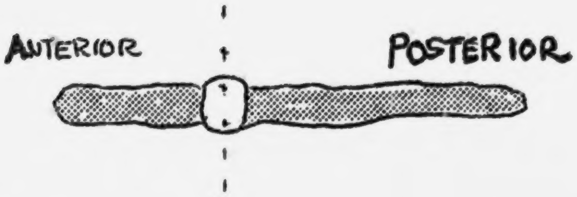
Obtain four or five earthworms of nearly equal length. Fill seven cans or flower pots about two-thirds full of humus or topsoil. With a razor blade, cut one earthworm into two parts by dividing it at a point about one-fourth of the distance from the anterior to the posterior end. (See diagram A below.) Cut a second worm into halves. (See diagram B below.) Cut the third worm at the smooth band around its body, clitellum. (See diagram C below.) Place a whole worm in one of the cans. (See diagram D below.) Label each can or pot with the type of cutting made. Set aside and examine daily for several weeks. Be sure that all pieces of worms are covered by soil. Which portions of the earthworms are still alive? Which portions show that regeneration has taken place? Keep a daily record.



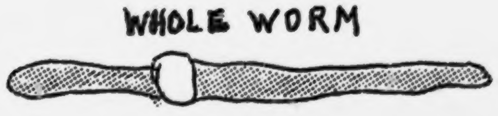
A



B



C



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*Miller and Blaydes. Methods and Materials for Teaching Biological Sciences. York, Pa: McGraw-Hill, 1938.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

CONJUGATION IN SPIROGYRA

PURPOSE

To induce conjugation in Spirogyra in the laboratory classroom for student examination.

ACTIVITY MATERIALS

Spirogyra culture
0.2% Knop's solution
Calcium Nitrate
Potassium Nitrate
Potassium Dihydrogen Phosphate
Magnesium Sulphate
Ferric Phosphate

WHAT TO DO

Place spirogyra in a 0. 2% Knop's solution for about two weeks. Remove the filaments and place them in distilled water in direct sunlight. Tap water may be used if necessary. The filaments should conjugate overnight. Observe under the low power of the microscope and make drawings or sketches of the various stages of conjugation. (10 ml of 1.5% Knop to 65 ml of distilled water)

Prepare Knop's solution:

Dissolve the following in a liter of water. This will make a 1.5 Knop's solution, usually used in full strength.

Calcium Nitrate $(Ca(NO_3)_2 \cdot 4H_2O$	0.8 gm
Potassium Nitrate KNO_3	0.2 gm
Potassium Dihydrogen Phosphate KH_2PO_4	0.2 gm
Magnesium Sulphate $MgSO_4 \cdot 7H_2O$	0.2 gm
Ferric Phosphate $FePO_4$	trace

LIFE CYCLE OF THE MOSS

PURPOSE

Growing the moss spores on culture media in the classroom laboratory for student observation

ACTIVITY MATERIALS

Ripe spore cases of moss
Culture media
Agar
Distilled water
Petri dishes
Absorbent cotton

WHAT TO DO

Add two grams of agar to 98 ml of 1.5% Knop's solution as suggested on p. 360. Boil this mixture until the agar dissolves and restore the volume up 100 ml with distilled water. Filter this through absorbent cotton in Petri dishes so that a layer about .3 cm thick is formed. Replace the top of the Petri dish and allow it to cool.

Place the spores from a ripe spore case of a moss plant on the culture medium. Germination usually takes place within 10 days after the spores have been placed on the medium. Observe the developing protonema under the microscope. Buds and the young gametophyte usually appear within three months. After the gametophytes have been growing for several months, flood them with water for about an hour. Drain off the excess water. Make a microscopic examination of some of the last droplets of water. Examine the surface of the plant microscopically. What do you observe? What is the purpose of the flooding?

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

POLLEN GRAINS

PURPOSE

To understand and learn that pollen is the male gamete in flowering plants

ACTIVITY MATERIALS

Pollen from plants such as sages (Salvia), mints, and snapdragon.
Ripe anthers from flowers of the lily family such as gladioli, lily, and others.
10% sucrose solution (cane sugar)
2% to 20% solution of sucrose
10% sucrose solution with boric acid (10 parts per million)
Mineral oil, glycerine or vaseline (petroleum jelly)
Microscope slides

WHAT TO DO

Clean two microscope slides thoroughly. Label one slide 10% sucrose, or S, and the other slide boric acid, or B. Place a drop of 10% sucrose solution on slide one and a sucrose-boric acid mixture on slide two. Shake a ripe anther from a lily over each drop until you can clearly make out the pollen grains in the fluid.

Carefully add clean cover slip to each slide. Do not press the cover slip. Examine each slide under the low power of the microscope to be sure you have not crushed the pollen grains. Now set aside each slide for about 10 minutes. After the ten minutes have elapsed, check each slide under the low power of the microscope. Make sketches of changes that have taken place. Check the slides at five-minute intervals for about 20 minutes. What changes have taken place since the first observation? What is the purpose of this tube? How do the sperm cells get to the ovary?

Shake pollen from various plants onto several petri dishes containing sugar solutions of varying strengths. Allow grains to remain in solutions for about two days. Observe a speciman under the microscope to see germinating pollen tubes. Keep a record of the solution strength and type of pollen and the length of time for pollen tube to grow.

Sucrose-boric acid solution: Dissolve 10 grams sucrose in 100 ml of water. Dissolve 0.1 grams boric acid in 100 ml of water, then dilute to 1000 ml with water. Add 10 ml of this boric acid solution to 100 ml of 10% sucrose solution.

To study the shapes of pollen grains, mount grains on a microscope slide in a drop of mineral oil, melted glycerine, or petroleum jelly. Observe under low and high power of the microscope.

Pollen grains may be stained by using aniline oil with crystal violet. Mount pollen grains in a few drops of tinted aniline oil on a slide. Hold the slide over a Bunsen burner flame until the pollen grains stain deeply, but do not let the slide become warm to the touch. Let the slide cool and remove the excess oil with filter paper. Wash several times with xylol by adding drops of xyol to the slide, then drawing it off with filter paper until the excess stain has been removed.

Observe pollen grains under the low and high power of the microscope. Make sketches of all examinations. Are the shapes of pollen grains different for different flowers? Are the sperm nuclei visible after staining? Make observations of the pollen germinating. Make sketches of these germinating grains. How does the sperm reach the egg cell in the flower? What is the purpose of the pollen tube? How many sperm cells are there in a pollen grain?

Reference:
Morholt, Evelyn et al. A Sourcebook for the Biological Sciences. New York: Harcourt, Brace, and Co., 1958, pp. 179 and 184.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

FERTILIZATION AND DEVELOPMENT IN SEA URCHIN EGGS

PURPOSE

To help in understanding the process of fertilization and the development of the zygote.

ACTIVITY MATERIALS

Scalpel
Finger bowls
Stereomicroscope
Pipettes (medicine dropper)
Fresh sea water
Live sea urchins
Forceps
Cheesecloth (15 cm X 15 cm)
Potassium chloride solution
Syringe
Electrical current

WHAT TO DO

Electrical Method

Place lead electrodes (made from lead tubing or heavy lead wire) at any two points on the shell of the animal, which lies, aboral side up, covered with sea water. Using an ordinary 60-cycle alternating current with 110-voltage, reduced to 10 volts by a transformer, will produce enough current to cause eggs and sperms to shed from each of the five gonopores; the sperms will be in a thin white thread; the eggs in a thick red thread. When the current stops, the shedding ceases. Remove the eggs at once, being sure to keep the sperms and eggs in separate culture dishes until ready to use for fertilization.

Potassium Chloride Method

Inject normal saline NaCl or 0.5 cc of 5.M KCl solutions into the mouth, through the teeth, to induce shedding.

Add Sodium periodate (5×10^{-5} M) to the sea water. Immerse the sea urchin until it is half covered with sea water (and Sodium periodate). Inject o.5 cc of 0.5 M KCl into the body cavity. Allow the eggs to be shed into a culture dish without sea water. Use eggs and sperm for fertilization procedures immediately.

Removal of Gonads

Place the sea urchin oral side up and cut around the animal's shell with a scissors at about its widest circumference. Remove the upper part of the shell.

The gonads should be visible. The testes are white and the ovaries are red. Snip the ovaries at the duct and place in a culture bowl about ½ full of fresh sea water. Allow the ovaries to stand in the bowl for about five minutes so that the ripe eggs may flow out of the ovaries. Place a piece of cheese cloth over the culture bowl and pour the egg suspension through this into another bowl of fresh sea water. If the eggs are to be kept for several hours, place a thin layer of eggs in a finger bowl, keeping the bowl covered so that little evaporation is allowed to take place.

Reference: Harvey, Ethel B. The American Arbacia and Other Sea Urchins. Princeton, New Jersey: Princeton University Press, 1956, p. 49 and pp. 57-58.

An approximate schedule of development at 23° C for Arbacia punctulata (East Coast species)*

Sperm comes into contact with egg	0 minutes
Completion of fertilization membrane	2 "
Union of pronuclei	8
Completion of hyaline layer	20
Streak stage	20-35
Nuclear membrane breaks	35
Prophase	35
Metaphase	40
Anaphase	42
Telophase	45
1st cleavage	50
2nd cleavage	78
3rd cleavage	103
4th cleavage	130
5th cleavage	157
Blastula (about 1000 cells)	7-8 hours
Gastrula	12-15 hours
Skeleton begins	19 hours
Pluteus (larva)	1 day

*Schedule of development in West Coast species Strongylocentratus purpuratus may differ slightly.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

DEVELOPMENT IN A FROG EGG

PURPOSE

To observe and record the development of a fertilized frog egg.

ACTIVITY MATERIALS

Slides and cover slips
Battery jars
Microscope
Frog eggs
Gravel
Water plants

WHAT TO DO

In early spring, collect a batch of frogs' eggs from a pond or slow moving stream. Divide the eggs into groups of 15 or 20. Raise each group of eggs separately in large battery jars or aquaria containing a layer of gravel and some water plants. When the young tadpoles appear, feed them small amounts of plant material and tiny bits of meat. Remove any unused food or dead eggs. (These turn white in color). As the tadpoles develop, watch for appearance of the hind legs. Later the front legs will appear. When this happens, lower the water level to about one-half inch or less, so that the animals can sit comfortably on the gravel. At this stage, the young frogs need living food, such as tiny insects and small worms (meal worms). If you cannot feed them, return the tadpoles to the pond.

Student teams observe several eggs every day under the stereomicroscope or a tripod lens. Record changes in data book. Make sketches of the development of a frog egg.

OBSERVING SPERM CELLS

PURPOSE

To observe and record the shape and movement of sperm cells.

ACTIVITY MATERIALS

Freshly-killed frog
Frozen bull sperm
Microscope
Glass rod
Slides and cover slips
Pipette
Small culture dish or beaker

WHAT TO DO

Dissect a male frog (identified generally by thick padded thumbs) and remove the testes. Crush one of them in a small dish with a little water, using a clean glass rod. Drop some of the milky fluid on a slide and examine it under the high power lens of the microscope. How do sperm cells move? Make a sketch of several sperm cells.

Order frozen bull sperm on the fresh materials order from the Science Center. Sperm must be used immediately or stored on dry-ice. Freezer is not cold enough. Place a drop of bull sperm on a slide and examine it under the low and high power lens of the microscope. What is the general difference in shape of a frog and bull sperm? How does the sperm cell move about? Make a sketch of several bull sperm cells.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

ARTIFICIAL INDUCEMENT OF FROGS' EGGS*

PURPOSE

To produce eggs and embryos for laboratory observations in the study of embryology.

ACTIVITY MATERIALS

- Pituitary suspension
- Female frog (living)
- Male frog (living)
- Alcohol
- Luer syringe with #18 needle
- Aquarium
- Forceps
- Holtfreter's solution ($NaCl$, KCl, and $NaHCO_3$)
- Pipette
- Microscope
- Slide and cover slip
- Petri dish
- Finger bowls

WHAT TO DO

Prepare a pituitary suspension which is to be injected into the female frog. In order to obtain the pituitary suspension, the following directions must be followed: Behead or pith a chloroformed frog. Remove the lower jaw. Make a slit with a fine pair of scissors into the braincase via the occipital foramen along each side of the cranium. Locate the pituitary gland, which is on the exposed ventral surface of the brain. It can be recognized as a pinkish, ovoid body lying across the brain. Remove the gland and place it in absolute alcohol. Remove the anterior pituitary gland. Sometimes it remains attached to the deflected bone. Three pituitary glands are necessary for one injection, and these are drawn up in a 1 cc. of absolute alcohol into a 5 cc. luer syringe with a #18 needle attached. Inject the female frog about 1/4 inch into the abdominal cavity, slanting the needle so that it does not puncture the organs. The syringe should be emptied into the frog. The frog is placed in a tank for 48 hours, with water just covering the bottom.

At the end of the 48 hours dissect out the spermaries of two frogs and macerate them in 10 cc. of distilled water (or pond water). Allow this to stand a half hour in a glass dish 6 inches or more in diameter. Hold the injected female above the sperm suspension and, with gentle pressure with thumb and forefinger in the region of the armpits of the female frog, force the eggs out into the suspension. A half hour later the eggs should be flooded so that the membranes may swell and development allowed to proceed. The first cleavage should occur within a few hours, if the water is kept at room temperature.

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*Reference from Turtox Service Leaflet No. 31, "Frog Eggs"

REPRODUCTION OF FISH IN AN AQUARIUM

PURPOSE

To make observations of sexual reproduction in live-bearing fish from a classroom aquarium.

ACTIVITY MATERIALS

Aquarium
Filter equipment for aquarium
Heating equipment for aquarium

Fish such as Guppies, black Mollies and others
Sand or gravel
Water plants

Prepare an aquarium for the classroom. Use water plants that will give new-born young cover and protection. Guppies are viviparous fish that are easily bred if the water in an aquarium can be kept at an average temperature of from 70° to 76° F. Keep a pair of guppies in an aquarium stocked with thick bushy water plants, particularly on the side toward the light. The male is smaller and more brightly colored. The female is much plumper, especially when she is carrying young. Observe the aquarium every day until female has given birth to young. Remove adult guppies to another tank, allowing the young to develop. Guppies are cannibalistic and will often feed on new born young. Feed adult fish on prepared fish food, or insects. Feed the young on finely-powdered fish food.

Keep a record of all activities of female and male guppies before birth of young and after birth of young. Make observations of the development of the young for several weeks and record information in data book.

For further information on raising tropical fish, use reference Innes, Exotic and Tropical Fish

STUDYING THE CHICK EMBRYO

PURPOSE

Comparing fertilized eggs of three to five days of incubation with an unincubated fertilized egg to study advances that have taken place in the development of a chick embryo.

ACTIVITY MATERIALS

Fertilized chick eggs
Culture dishes
Scissors
Pipette (medicine dropper)
Paper towels
Forceps
Incubator

WHAT TO DO

With a soft lead pencil, carefully write the date of beginning incubation on each fertilized egg as it is placed in the incubator. The fertilized eggs should be stored at a cool 10° C when not incubated, but should be used within the week after they have been laid. A longer period of time than this reduces the viability of the egg.

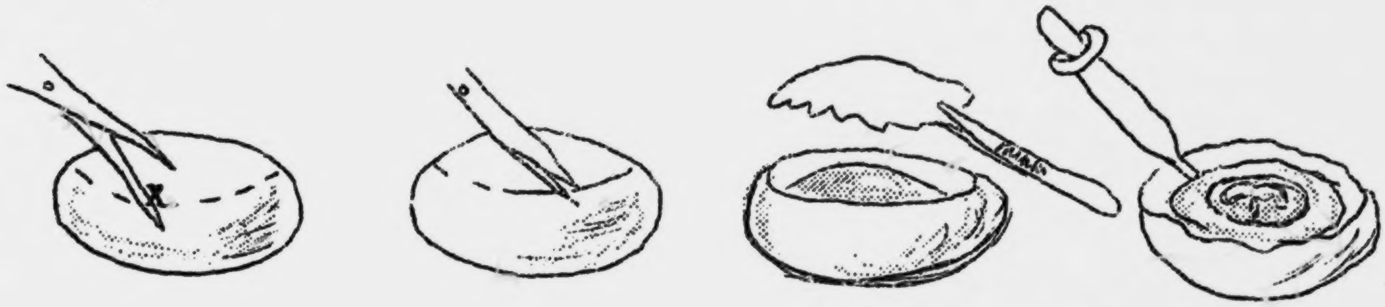
Place an "X" mark on one side of the egg to indicate when a 180° turn has been made. Turn or rotate the eggs in the incubator every 24 hours. This prevents the embryo from sticking to the hard shell membrane. When the eggs are first placed in the incubator, they are usually cold, and a certain amount of time must be allowed to bring their temperature to that of the incubator. The pre-heating period is approximately four hours. Therefore, when incubating eggs allow the four-hour interval to elapse before starting to count the incubation period desired. Eggs should be incubated at a constant temperature, 37° C.

Remove eggs after three days have elapsed and after five days have elapsed. This should involve one laboratory period to observe all three eggs. Eggs for the five-day incubation should be placed in the incubator earlier than the eggs for the three-day incubation period.

When removing the eggs from the incubator, do not rotate them any more than necessary. Keep the eggs in the same relative position as you place them in the labeled culture dishes. Crumple several paper towels to make a mound on which to place the fertilized egg. Allow the egg to remain in a stationary position for several minutes on the mound of crumpled paper toweling before starting the observation. This allows the embryo to be at the top of the yolk.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

Remove the shell from each egg, as illustrated in diagram below.



Insert point of scissors carefully to puncture the shell at point marked X. Carefully and slowly cut the shell completely around the egg. After egg has been cut completely, lift the loose piece of shell with a forceps and discard it. Using the pipette, carefully draw off albumen until the yolk surface is not covered and the embryo clearly noticeable. Place entire culture dish under the steromicroscope and make observations. Make sketches of the embryo of five-day, three-day, and unincubated eggs. Make the following comparisons:

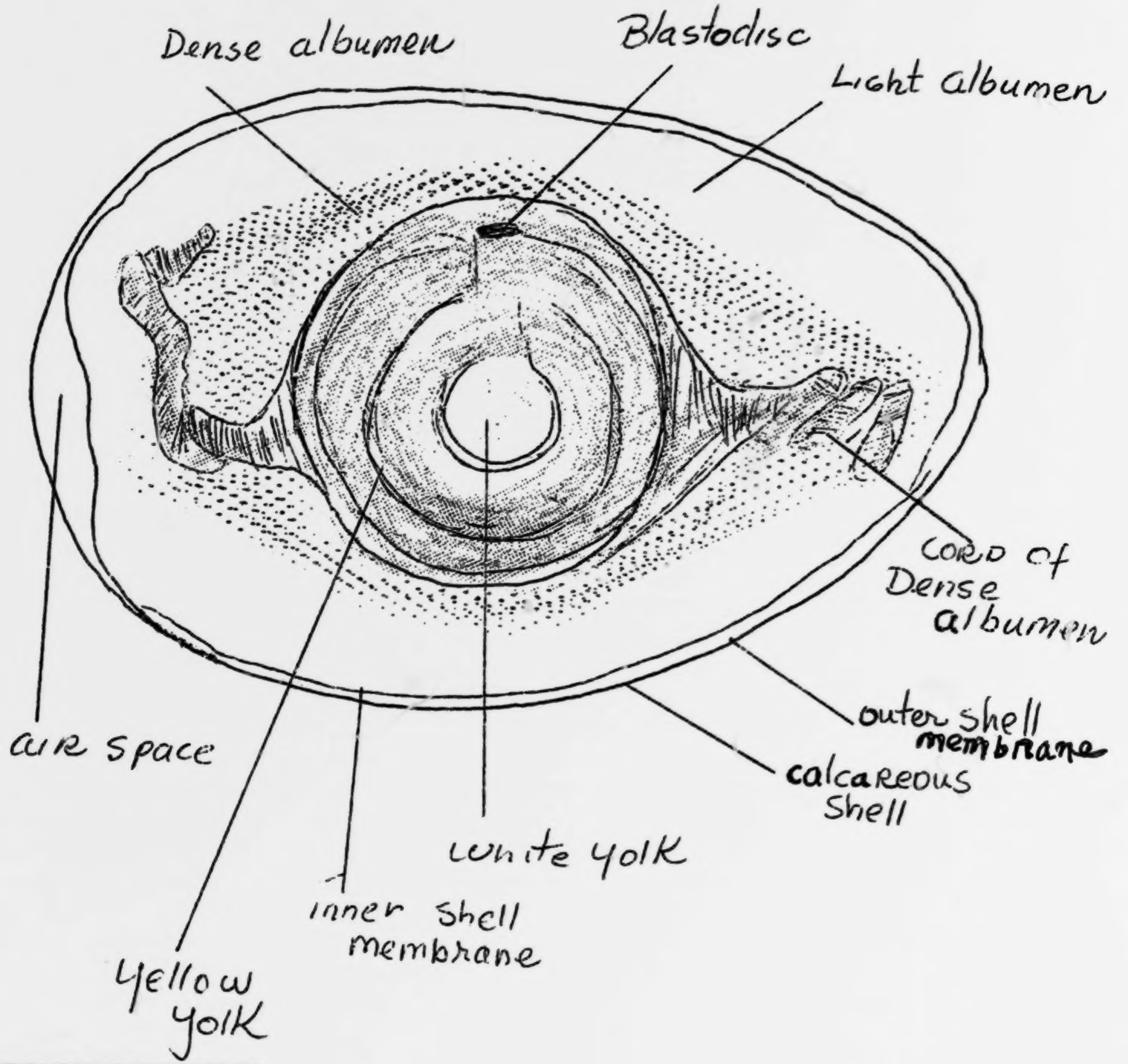
Unincubated egg-- note the yolk and the blastodisc. What part will develop into the embryo? What development has taken place since the egg was laid? Compare the size of the blastodisc in the unincubated egg and the three-day embryo.

Three-day embryo-- Note the yolk and the blastodisc. What structures are evident at this stage? What is the function of the blood vessels radiating from the embryo? Is the heart beating in this embryo? What will the paired somites develop into in later stages?

Five-day embryo--Observe the membranes surrounding the embryo. Note the yolk sac which covers part of the yolk. What is its function? What is the function of the balloonlike sac (allantois)? Is the heart beating in this embryo? Has further development of the somites taken place in this embryo? Does this embryo have a tail? a neck? Does the embryo begin to show wing or leg development? Compare the relative size of the eyes and the brains of the three-day and five-day embryos.

Demonstration observations should be made of the following, using prepared slides.

13 hours will show the primitive streak
18 hours will show the primitive streak and head process
24 hours will show several somites and the nervous system (well on its way)
33 hours will show heart (no circulation has begun)
48 hours will show that circulation is well established
72-96 hours, most of the organs are well established


Dense albumen
Blastodisc
Light albumen
Cord of Dense albumen
outer shell membrane
calcareous Shell
air space
white yolk
inner shell membrane
yellow yolk

References:
Miller and Blaydes. Methods and Materials for Teaching Biological Sciences. York, Pa.: McGraw-Hill, 1938, p. 402
Turtox Service Leaflet No. 43. "Embryology in the High School Biology Course"
Turtox Service Leaflet No. 17. "Incubation, Fixation and Mounting of Chick"
Menzel, Mark. American Biology Teacher. "Embryological Studies for High School Biologist," Jan. 1954.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

HOMEMADE INCUBATOR

PURPOSE

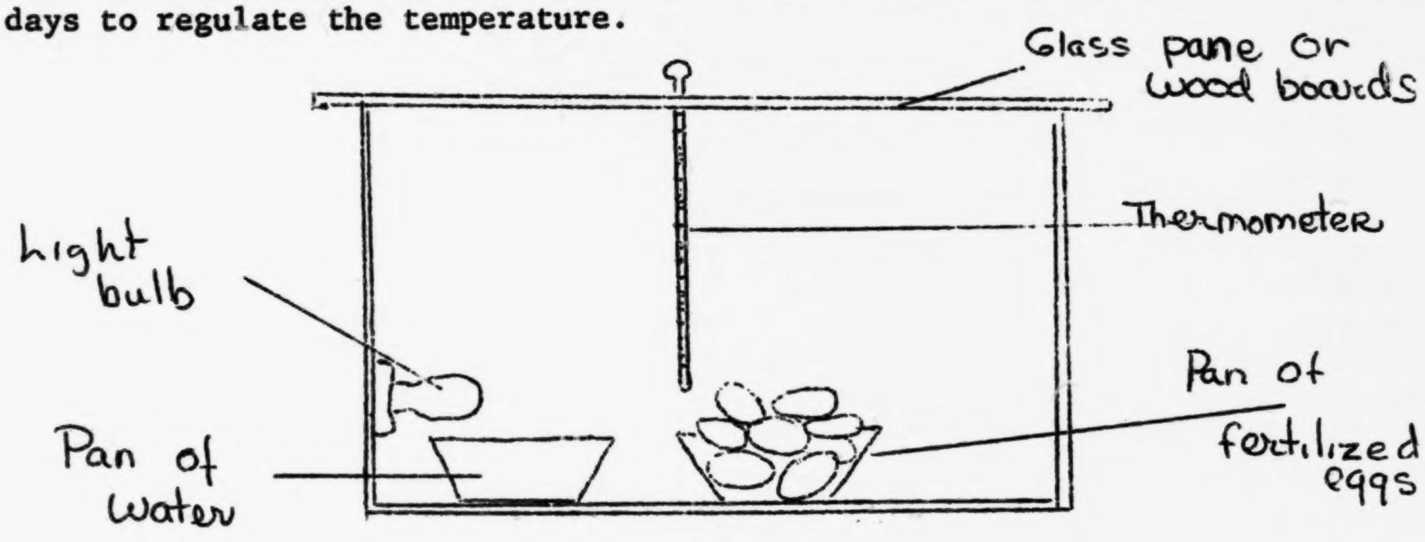
To build a working incubator for home or classroom use in the study of chick embryology.

ACTIVITY MATERIALS

- Store box of wood (apple box)
- Two boards or panes of glass
- Electric light socket
- Thermometer
- Two pans (or trays)
- Corrugated paper or heavy wall board

WHAT TO DO

Cover the walls of the wood box with corrugated paper or wallboard if the walls are thin or cracked. Install the electric light in one end of the box. This is to serve as a heating unit. Place both pans in the box, one directly under the light. Fill this pan with water. Fill the other pan with the fertilized eggs. Set the panes of glass or boards over the top of the box. The panes should be pushed close together, and the thermometer hung between them so that its bulb is near the pan of eggs. Turn on the light and keep a record of the temperature for several hours. If it rises above 37° C correct this by opening the space between the two boards or panes at the top of the box a little. If the temperature cannot be controlled, use a weaker bulb. If the temperature fails to rise to 37° C, use a stronger bulb. Be sure not to place the eggs in the box until a constant temperature is maintained. It may take two or more days to regulate the temperature.



Miller & Blaydes. Methods and Materials for Teaching Biological Sciences. York, Pa.: McGraw-Hill, 1938, p. 402. Used by permission.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

CYTOCHROME OXIDASE IN THE CHICK EMBRYO

PURPOSE

Comparing the amount of cytochrome oxidase in chick embryo tissues from three to five days old.

ACTIVITY MATERIALS

Chick embryos (Three and five days old)
Saline solution
NADI solution
  Alpha-naphthol
  Dimethyl-p-phenylenediamine (PPD)
  Phosphate buffer (pH 5.8)

WHAT TO DO

Remove an embryo from the yolk and rinse it in warm saline solution. Draw off the saline solution with a pipette and replace it immediately with warm NADI reagent. Record the time the NADI reagent is placed on the embryo. Record the time for the first trace of blue color to appear and continue to record its locations and extent at three-minute intervals.

Compare the results of the experiment with those of other members of the class. Some experiments may be using older or younger embryos. NADI is oxidized to a blue pigment (indophenol) in the presence of oxygen by cytochrome oxidase.

Preparation of NADI reagent:

> This reagent should be prepared prior to its use in the laboratory. Combine equal parts of 0.01-M alpha-naphthol, 0.01 -M dimethyl-p-phenylenediamine (PPD), and phosphate buffer, pH 5.8.
>
> Dissolve 1.44 grams of alpha-naphthol in one liter of physiological saline (0.9% NaCl solution). Heat to dissolve. Dissolve 1.36 grams of dimethyl-p-phenylenediamine in one liter of physiological saline. Phosphate buffer is a mixture of 9.5 grams of Na_2HPO_4 + one liter of distilled water. KH2PO4 (9.5/1 liter of distilled water). Mix the two solutions mentioned as follows: 7.8 mm of Na_2HPO_4 solution to 92.2 mm KH_2PO_4 solution.

Adapted from George Wald, Peter Albershein, John Dowling, Johns Hopkins, III, and Sanford Lacks. Twenty-Six Afternoons of Biology. Reading, Mass.: Addison-Wesley, 1962. pp. 124-125. Reprinted with permission of publishers.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

CONCEPTS TO CONSIDER

Each cell of every organism of a given species contains a characteristic number of chromosomes.

Chromosomes always exist in pairs.

The appearance (morphologic or physiologic) of an organism with respect to a certain inherited trait is known as its phenotype.

The living organism's genetic composition is known as its genotype.

The exchange of chromosomal segments occurs at random along the length of the chromosome in crossing-over.

The greater the distance between two loci of any two genes in the chromosome the greater will be the chance that an exchange of segments will occur between them.

All genes in a particular chromosome constitute a linkage group.

Linkage groups remain constant and are only changed by a translocation in which a piece of one chromosome breaks off and becomes attached to another nonhomologous chromosome.

Multiple alleles are three or more alternate conditions of a single locus which produce different phenotypes.

Genes exist in living organisms in pairs, and in the formation of gametes each gene separates from the other member of the pair and passes into a different gamete.

Each gene controls the appearance of a single trait.

Several pairs of genes may interact to affect a single trait, or one pair may inhibit or reverse the effect of another pair of genes; or a given gene may produce different effects when the environment is changed in some way.

When two pairs of genes are located in different (nonhomologous) chromosomes, each pair is inherited independently of the other.

When an offspring shows a phenotype intermediate between that of two parents this is termed incomplete dominance.

A recessive gene is one which will produce its effect only when homozygous (both genes of the pair of chromosomes are recessive).

A dominant gene is one which will produce its effect whether it is homozygous or heterozygous.

The gene for each trait occurs at a particular point in the chromosome called a locus.

The inheritance of any trait can be studied only when there are two contrasting conditions.

The amount of DNA is constant in all cells of the body, and the amount of DNA in germ cells is only half the amount.

The DNA molecule is composed of two long chains of sugar and phosphate groups, with cross links of four nucleotides: adenine, thymine, guanine, and cytosine.
It is thought, under normal conditions, that adenine pairs only with thymine and guanine pairs only with cytosine (specific pairing hypothesis).
A gene is the part of the hereditary material which has to do with determining the amino acid sequence of a specific protein.
Chromosomes contain protein and nucleic acid, which are able to replicate themselves and cause enzyme synthesis.

TEACHING APPROACH (Methods and Activities)

Discuss the Chromosome Theory of Heredity

-Review the work of Gregor Mendel with the class. Encourage some students to read the original writings of Gregor Mendel in Gregor Mendel, Experiments in Plant Hybridization, Harvard University Press, Cambridge, Mass., 1941.
-Discuss the number of chromosomes in various living organisms. Assign students to make a list of the number of chromosomes for these organisms.
-Briefly review meiosis and gametogenesis in relation to understanding Mendelian inheritance.
-Introduce the terms dominant and recessive by using laboratory experiment on p. 384.
-Discuss the mechanism of a monohybrid cross showing dominant and recessive traits. Instruct students in a model cross showing Mendelian inheritance. Demonstrate the phenotype and genotype ratios. Show F_1 + F_2 generation. Do a backcross.
-Explain the law of segregation. Use the chalk board or the flannel board to point up this concept. A good example is the use of red four o'clock flowers mated to white four o'clock flowers to produce pink four o'clock flowers. Continue to the F_2 generation to show that pink does not breed true.
-Explain the law of independent assortment. Use the chalk board or the flannel board to point up this concept. A good example is the use of a pure black rosetted Guinea pig mated to a pure white smooth Guinea pig. Continue to the F_2 generation to show that gene pairs located on homologous chromosomes will assort independently (be expressed independently) and are unaffected by the simultaneous inheritance of other gene pairs located on other homologous chromosomes.
-Give an explanation of the law of linear order. Discuss linked genes on a given chromosome. Assign some students to report on the work of T. H. Morgan. Show a cross on the chalk board describing the action of linked genes. Describe a locus.

- Discuss the effect of crossing-over of chromosomes and how this process can change inheritable variations. Review meiosis and crossing-over.
- Discuss incomplete dominance. Show a model cross on the chalk board describing the action of incomplete dominance.
- Discuss a dihybrid cross. Show a model cross on the chalk board. Assign students problems for homework showing complete dominance, incomplete dominance, and dihybrid crosses.
- Start Drosophila cultures and proceed with F_1 and F_2 cross of any two pure genetic strains available from Science Center.
- Give a thorough explanation of laboratory procedures in Drosophila culture. If sets of Drosophila Guide (M. Demerec and B.P. Kaufmann-Carnegie Institution of Washington, D. C., 1962) are available, assign students to read various sections to help in understanding of procedures to be used in class. See experiment on pp. 386-91.
- Discuss chromosomal maps. See activity p. 392 to help in giving a description of the loci of various mutations and normal characteristics of Drosophila. Encourage a student team to prepare a bulletin board entitled MAPS OF DROSOPHILA CHROMOSOMES.
- Discuss the concept of probability. Encourage some students to report on probability predictions.
- To illustrate probabilities in genetic ratios, do laboratory experiment suggested on pp. 393-94.
- Discuss variations in plants and animals.

- Discuss multiple alleles as in blood types of humans and eye color in Drosophila.
- Discuss multiple factors. Do a cross showing that the cumulation of particular genes will cause a change in the phenotype expression. Studies on wheat showing variations in color of red kernels...when parents of hybrid condition white and red genes were mated together. Skin color differences in humans.
- Discuss sex-linkage. Do a cross showing the resulting offsprings in colorblindness and/or hemophilia.
- If the Ishihara Test for colorblindness is available in your science department, plan to give this test to various members of the class.
- Discuss lethal genes. Do a cross illustrating lethal genes.
- Discuss non-disjunction. Cite red-eyed males and white-eyed females as examples in Drosophila studies. Encourage a student to report on non-disjunction in humans. Assign a student to report on the work of C. B. Bridges.

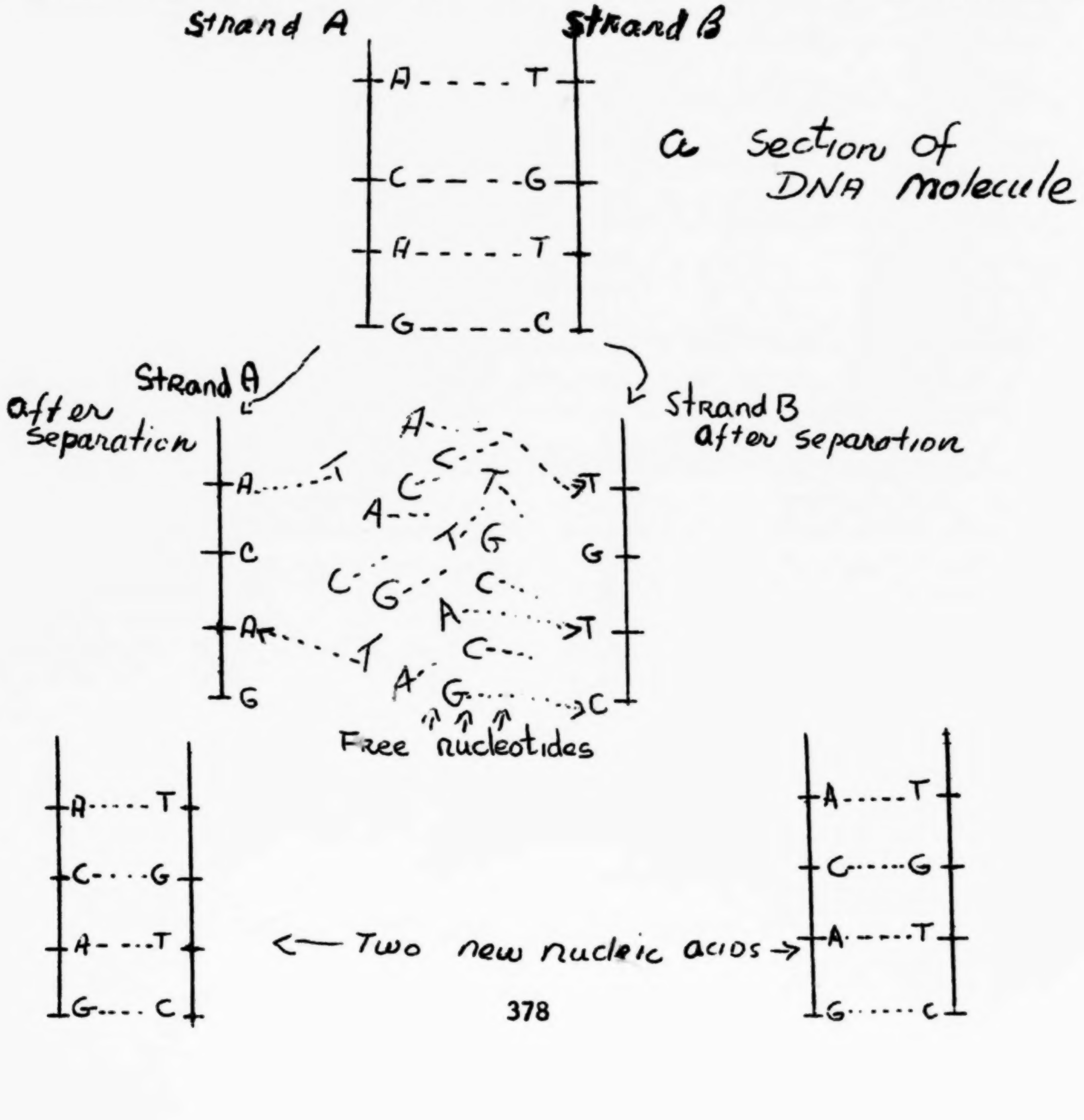
Discuss the nature of the gene.

- Discuss the molecular structure of a gene.
- Give an explanation of the structure of DNA and RNA, and where it is found in the cell.

- -Demonstrate the structure of DNA and RNA through the use of the flannel board. See suggested activity on p.395-98 Discuss the Specific Pairing Hypothesis.
- -Discuss the various methods that scientists have used to discover the shape of a DNA molecule. Discuss Pauling-Corey protein model.
- -Discuss the Watson-Crick model of a DNA molecule. Discuss the term helix.
- -Discuss the difference between DNA and RNA in structure & function.
- -Encourage some students to read articles listed in teacher reference on p. 382 from Scientific American.

Discuss the reproduction of genetic material and gene action.

- -Discuss replication of DNA. Use cutouts of flannel board demonstration suggested on p. 395.
- -Draw diagram given below on the chalkboard to help students in understanding replication in DNA. This is a very simplified method of this process.


Strand A
Strand B
A T
C G
A T
G C
a section of DNA molecule
Strand A after separation
Strand B after separation
Free nucleotides
Two new nucleic acids

- Discuss experiments that have been done to prove DNA is in the gene. Transformation in pneumococci and certain other bacteria. Experimentation with bacteriophages to show transduction.
- Discuss (if student ability level is able to comprehend) coding system theory. An excellent paperback for student information is Issac Asimov, The Genetic Code Signet Book. New American Library: New York, 1963.
- Discuss "Messenger RNA," "Transfer RNA" as used in protein synthesis in ribosomes of cell. Discuss the "one gene - one enzyme" hypothesis.

Discuss the mechanism of heredity.

- Discuss genetics--plant and animal breeding. Students make a list of plants that have been improved through genetics.
- Encourage some students to read about Luther Burbank.
- Make a list of the various animals that have been improved through genetics.
- Explain hybrid vigor.
- Students experiment with tasting PTC. Tabulate results for all classes and make comparisons with national averages.
- Assign students to prepare a family history chart on a particular trait.
- Discuss family history charts of Queen Victoria showing hemophilia, Juke family showing poverty, and the Kallikak family showing feeblemindedness.
- Encourage several students to bring in pedigree papers of their dogs, cats, or horses. Discuss pedigree papers and their meaning.
- Discuss identical and fraternal twins and other multiples.
- Prepare a bulletin board entitled YOU AND HEREDITY.

DEPTH PROBE

- HOW GENES ACT, p. 384 (Average Student Basic Activity)--To demonstrate the concept of dominance and recessiveness in gene action. Students work in pairs.

- DISTINGUISHING MALE AND FEMALE DROSOPHILA MELANOGASTER, pp. 386-389 (Average Student Basic Activity)--To learn the techniques used in growing fruit flies in an attempt to carry on genetics experiments in the laboratory classroom. Students work in pairs or in teams.

- CROSSING DROSOPHILA OF TWO DIFFERENT GENETIC STRAINS, pp. 390-391 (Average Student Basic Activity)--To learn concepts concerning dominance and recessiveness and correlating these to Mendelian principles. Students work in pairs or in teams.

- CHROMOSOMAL MAPS, pp. 392 (More Able Student Basic Activity--Optional)--To learn that genes are found at a particular position (locus) on a specific chromosome in Drosophila. Students use this as a demonstration display.

- PROBABILITY AND GENETIC RATIOS, pp. 393-394 (More Able Student Basic Activity)--To understand some of the fundamental laws of probability and how they apply to the biology of inheritance. Students work in pairs or in teams.
- STRUCTURE OF DNA AND RNA, pp. 395-398 (Average Student Basic Activity)--To learn and understand the structure of DNA and RNA. How it replicates itself; and about the theory of coding. Teacher Demonstration.

"TOOLS" FOR EXTENDING CONCEPTS

- Plan to show films
    - "DNA: Molecule of Heredity" Fsd 574.8-3
    - "Heredity in Animals" Fsd 575.1-2
    - "Heredity" Fsd 575-1
    - "Heredity and Environment" Fsd 575.1-1
    - "The Thread of Life" Part 1 and Part 2 Fsd 575.1-3
- Plan to show filmstrips
    - "Great Names in Biology: Gregor Mendel" (set 6) S-102 (Science Department, blue box collection)
    - "Heredity" (Set 1) S-116
- Play transcription "The Scientists Speak"--only the part that has H. J. Muller's talk.
- Encourage an interested student to read and report on gene transduction as experimented by Dr. Joshua Lederberg.
- Encourage some students to read about Beadle and Tatum's work on Neurospora, the pink mold. Students may wish to try experiments using Neurospora as a special project.
- Assign an interested student to report on the work of American biologists on the nature of DNA. A good reference is Fortune, June 1960.
- Help students prepare a list of traits that may be used in preparing a family history chart.
- Several students may tabulate members of the class as to whether they have some of the following traits: tongue-curling trait, handedness, hair-whorling, widow's peak, and others.
- Encourage an interested student to build a three-dimensional model of DNA. Use reference Carleen Maley Hutchins, Life's Key--DNA New York: Coward-McCann, Inc., 1961. pp. 60-63.
- Encourage a student team to prepare a bulletin board entitled FROM MENDEL TO WATSON-CRICK, to illustrate an historical approach to genetics.
- Encourage an interested student to read about the future of DNA and protein synthesis and how they may be used in some forms of subcellular engineering.
- Encourage an interested student to give an explanation of the coding process hypothesis in DNA.
- Give an illustration of the coding process as shown in the insulin molecule.
- Assign an interested student team to explain to other members of the class the inheritance of blood groups, such as A, B, O, AB, M, N, MN, Rh.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

PLANNING AHEAD

- Assign students to bring in two or three daisies, asters, or dandelions for experiment on variation.
- Locate and store several hundred lima beans and mm rulers.
- Locate calipers for cephalic measurements.
- Make arrangements with hospital or dentist friend to have several hundred seeds irradiated as per directions on p. 418.
- Locate and store paper cups or seed flats, vermiculite, petri dishes, and blotting paper.
- Prepare materials on the comparison of form to show change in horses by having information on p.433 dittoed for student use.
- Prepare a large bulletin board to show EVOLUTION OF THE HORSE.
- Encourage several students to read an article from Scientific American entitled "Sickle Cells and Evolution," Anthony C. Allison, Vol. 195, 1956 pp. 87-94.
- Locate and reserve prepared slides on sickle-cell anemia and normal blood cells for class observation.
- Prepare cutouts for the flannel board on moth evolution, showing industrial melanism as suggested on p. 428.
- Order guppies or other fish for making observations of blood in capillaries under microscope. See suggested activity on p. 429.
- Locate and reserve fossils of a variety of organisms. Encourage interested students to bring in their own models of skeletons of prehistoric animals for classroom display and discussion.
- Assign a student team to prepare a bulletin board entitled CHANGES IN LIVING THINGS.
- Order filmstrips on prehistoric life from 1961 Catalog of Audio-Visual Materials, Secondary Grades (Los Angeles City Schools, Division of Instructional Services, Audio-Visual Section. Publication 579, 1961) "Prehistoric Life" S-3.
- Assign students to try to bring in photographs of protective coloration in animals for a classroom bulletin board display.
- Encourage some students to report on mimicry in animals and plants and the reasons for this adaptation.
- Encourage students to locate information on adaptive radiation in a variety of animals and plants. Encourage some student to report on adaptive radiation in Darwin's finches. Good reference is David Lack, "Darwin's Finches," April, 1953, Scientific American.
- Encourage a student team to prepare a bulletin board showing beak and feet adaptations of birds FROM BILL TO FOOT.
- Encourage several students to prepare a large poster of the various kinds of dog breeds as shown in book Ruth Moore, Evolution, Time Inc., New York, 1962, pp. 86-87.

BROADENING "CONTENT HORIZONS"

Teacher References:

·Articles from Scientific American

-Beadle, G. W. "The Genes of Men and Molds" (Sept. 1948)
-Crick, James. "The Structure of the Hereditary Material" (Sept. 1948)
-Jacob, Francois and Elie Wollman. "Viruses and Genes" (June 1961)
-Horowitz, N. H. "The Gene" (Oct. 1956)
-Knight, C. A. and D. Fraser. "The Mutations of Viruses" (July 1955)
-Mirsky, A. E. "The Chemistry of Heredity" (Feb. 1953)
-Muller, H. J. "Radiation and Human Mutation" (Nov. 1955)
-Taylor, J. H. "The Duplication of Chromosomes"(June 1958)
-Sonneborn, T. M. "The Partner of Genes" (Nov. 1950)
-Benzer, S. "The Fine Structure of the Gene" (Jan. 1962)
-Hurwitz, J. and J. J. Furth. "Messenger R N A" (Feb. 1962)
-Ingram, V. M. "How Do Genes Act?" (Jan. 1958)
-Dobzhansky, T. "The Genetic Basis of Evolution" (Jan.1950)

Silvers, W. K. "Genes and the Pigment Cells of Mammals," Science (Aug. 1961)

-Crow, James. Genetics Notes. Minneapolis, Minn.: Burgess Publishing Co.

-Waddington, C. H. An Introduction to Modern Genetics. London: Allen and Unwin, 1939

-Stern, C. Human Genetics. 2nd Ed. San Francisco: Freeman, 1960.

-Wilson, E. The Cell in Development and Heredity. New York: Macmillan, 1947.

-Dobzhansky, T. Genetics and the Origin of the Species, 3rd Ed. New York: Columbia University Press, 1951.

-Holmes, S. J. Human Genetics and Its Social Import. New York: McGraw-Hill, 1936.

-McElroy, W. D. and B. Glass. Chemical Basis of Heredity. Baltimore: Johns Hopkins Press, 1957.

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-Srb, A. M. and R. D. Owen. Genetics. San Francisco: Freeman, 1952.

-Penrose, L. S. Outline of Human Genetics. New York: Wiley, 1959.

-Strauss, B. Chemical Genetics. Philadelphia: Saunders Co, 1960

-Wolstenholme, G. E. and C. M. O'Connor (Eds). The Biochemistry of Human Genetics. Ciba Foundation Symposium, Boston: Little Brown and Co., 1959.

Student References:

- Articles listed in teacher reference section from Scientific American
- Montagu, A. Human Heredity Mentor Books. New York: 1960.
- Goldstein, P. Genetics is Easy. New York: Latern Press, 1955.
- Bonner, D. Heredity. New York: Prentice-Hall, 1961.
- Dobzhansky, T. Evolution, Genetics and Man. New York: Wiley, 1955.
- Moore, R. The Coil of Life. New York: A. Knopf, 1961.
- Scheinfeld, Amram. The New You and Heredity. Philadelphia, Pa.: Lippincott, 1950. (Title III Collection)
- Auerbach, C. Genetics in the Atomic Age. Fairlawn, New Jersey: Essential Books, Inc., 1956.
- Shull, A. Heredity. New York: McGraw-Hill, 1948.
- Sinnott, E., L. C. Dunn, and T. Dobzhansky. Principles of Genetics. New York: McGraw-Hill, 1958.
- Snyder, L. H. and P. R. David. Principles of Heredity. 5th Ed. Boston: D. C. Heath, 1957.
- Mendel, Gregor. Experiments in Plant Hybridization. Cambridge, Mass: 1941 Harvard University Press
- Beaty, John. Luther Burbank, Plant Wizard. New York: Julian Messner, Inc. 1943.
- Glass, B. Genes and Man. New York: Columbia University Press, 1943.
- Sootin, H. Gregor Mendel: Father of the Science of Genetics. New York: Vanguard Press, 1958.

Textbook References:

- Smith, Ella Thea. Exploring Biology pp. 514-543.
- Moon, Otto, Towle. Modern Biology pp. 608-655.

HOW GENES ACT

PURPOSE

To demonstrate the concept of dominance and recessiveness in gene action

ACTIVITY MATERIALS

Test Tubes
Forceps
Pipe cleaners (White color)
Test-tube rack
Bromthymol blue solution
Paper towels
10% HCl
Distilled Water
Sodium Hydroxide

WHAT TO DO

Prepare bromthymol blue solution - (Buffer solution)

Take about as much bromthymol blue powder as will stick to half a wet toothpick.
Dissolve this in about 500 ml of hot tap water in a liter flask.
Add about 10 drops of dilute base (Sodium Hydroxide solution diluted 1:9).
This should turn the bromthymol solution deep blue.
Next add about 10 drops of a dilute acid to the indicator solution (dilute 10% HCl 1:99). Acid should turn the indicator bright yellow. Now while you vigorously swirl the contents of the flask, add the dilute base one drop at a time. Stop when the indicator turns blue-green. If you go past this point, add a drop or so of the acid.

Fill three test tubes with the bromthymol blue indicator to represent cells.

Soak three pipe cleaners in 10% HCl solution (for one-half hour). Soak three pipe cleaners in a weak, 1% Sodium Hydroxide solution (for one-half hour). Soak all pipe cleaners as suggested above immediately before experiment.

Place two pipe cleaners that have soaked in 10% HCl in one of the three test tubes containing the bromthymol blue. Mark this test tube AA. Place one pipecleaner from 10% HCl and one pipecleaner from 1% Sodium Hydroxide solution in a test tube containing bromthymol blue. Mark this test tube Aa. Place two pipe cleaners from 1% Sodium Hydroxide solution in a test tube containing bromthymol blue. Mark this test aa. See Figure 1.

Fill in data in chart given below:

	Chromosomes	Original "Cell" Color	Resultant "Cell" Color
Cell 1			
Cell 2			
Cell 3			

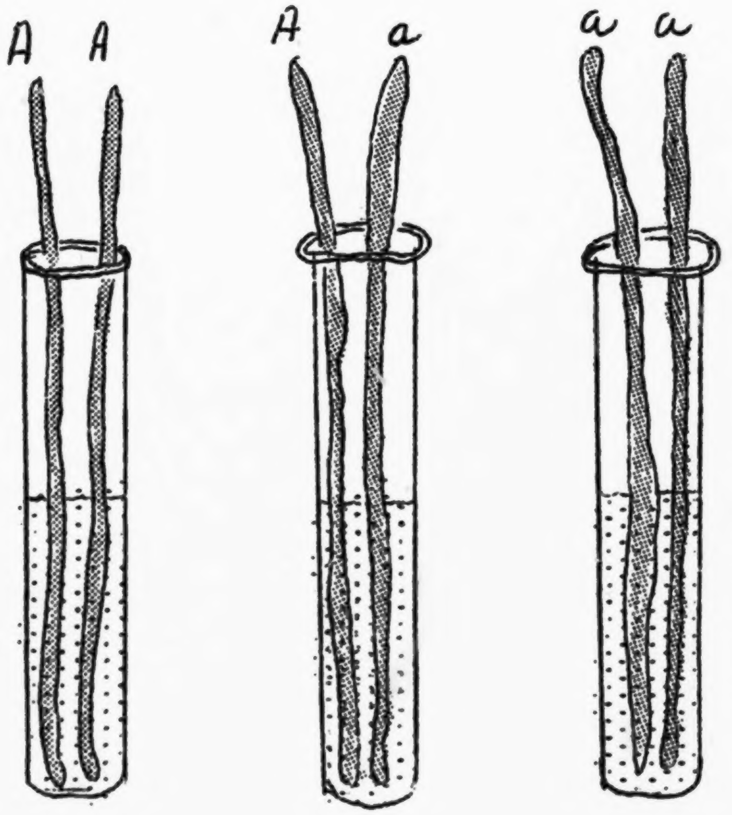


figure 1

DISTINGUISHING MALE AND FEMALE DROSOPHILA MELANOGASTER

PURPOSE

To learn the techniques used in growing fruit flies in an attempt to carry on genetics experiments in the laboratory classroom.

ACTIVITY MATERIALS

Etherizer
Morgue
Ice bath
Microscope or Stereomicroscope
Petri dishes
Plate glass covered with white paper
Vial containing 50 flies
Teasing needles with bent point
Absorbent cotton
Drosophila media (Order from Science Center)
Camel's hair brushes
20-50 ½ pint milk bottles (or baby food jars)

WHAT TO DO

Students may help to mix Drosophila media and pour into ½ pint milk bottles or baby food jars. Follow directions for mixing media enclosed by Science Center. Cotton plugs, ½ pint bottles, and strips of paper toweling should be sterilized at 15 lbs. pressure for 20 minutes (20 lbs. pressure for 15 minutes). Pour hot media into sterilized ½ pint bottles; insert paper strip into bottle and plug with cotton stopper. Cool media and store in refrigerator until ready to use.

Students should prepare cotton plugs and cut paper strips well in advance of the media preparation. Prepare cotton plugs so that they are covered by cheese cloth or bandage gauze. Mold the two together to form a sturdy plug to fit the opening of the baby food jar or ½ pint milk bottle.

Preparation of an etherizer: Insert a nail or an unbent paper clip into a cork stopper which fits the container. Hook a cotton ball covered with cheese cloth onto the nail or unbent paper clip. Place a few drops of ether on the absorbent cotton and immediately place the stopper into the container. (figure 1)

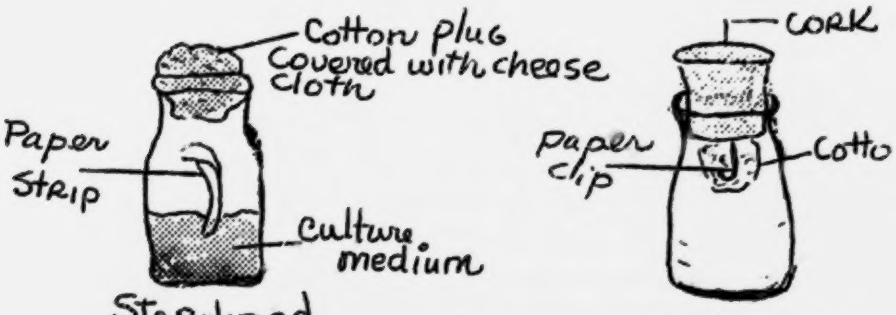
Preparation of a re-etherizer: Tape a cork stopper to the outside center of the cover part of a petri dish. Tape a cotton ball covered with cheese cloth to the inside center of this same dish. Flatten the cotton ball so that it does not touch the surface of the table when the re-etherizer is being used. Moisten the cotton ball with ether when ready for use. (figure 2)

Transfer the flies from the stock bottle to the etherizer by the following method. Place the mouth of the etherizing jar to the mouth of the stock bottle and hold the bottles firmly together (of course the stoppers must be removed before this can be accomplished, so act quickly). After the bottles are together, invert the stock bottle so that it is on top of the etherizer. Tap the stock bottle so that the vibrations will cause the flies to fall into the etherizer. Quickly separate the bottles and stopper both with the appropriate plugs. When the flies fall to the bottom of the etherizer and stop moving, pour them out onto a sheet of white paper or a plate glass covered with white paper. (figure 3)

Examine a single etherized fly at a time under a hand lens or stereomicroscope. Use a camel's hair brush, teasing needle, or cotton swab stick to move the flies around on the sheet of white paper. Quickly make the identification and move the flies into two piles, one for males and one for females. If the flies should awaken, use the re-etherizer..... try not to overetherize the flies.

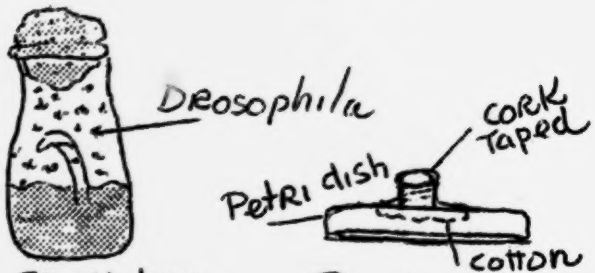
Cooling technique may be used instead of the etherizer. Place the flies in a bottle without media and plug with a cotton stopper. Put this bottle in a pan containing ice cubes and water. Upon cooling, the flies will fall to the bottom of the bottle. If the flies awaken, they can be cooled over and over again. (figure 4)

Preparation of Morgue: ½ pint milk bottle with 70% alcohol-- drop in all dead flies.



Sterilized Transfer bottle

Etherizer
Figure 1



Stock bottle

Re-etherizer
Figure 2

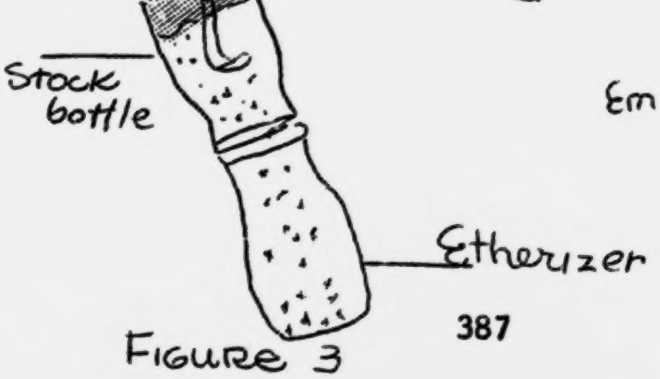


Figure 3

Em

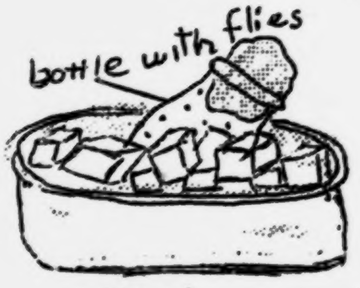


Figure 4

Cooling method

Identification of female and male flies:

Look for the distinguishing sex differences and record on the chart below.

ABDOMINAL MARKINGS and SHAPE

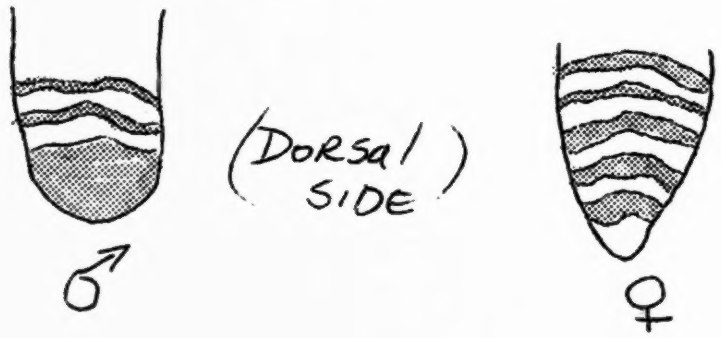


FIGURE 5

Distinguishing features	Male	Female
1. Relative total size (Which one is larger?)		
2. What kind of markings on the adominal region?		
3. What is the shape of the abdomen?		
4. Are external sex organs present?		
5. Are sex combs present on first leg?		

After the identification of a pure strain of flies has been made, prepare a small paper cone from paper toweling and fill the cone with equal numbers of male and female flies (about five of each). Insert the small paper cone into a fresh bottle of media. Insert the cotton plug and label the bottle with date, kind of pure strain flies and keep in a warm dark place. Prepare as many bottles of a particular strain of fly as needed. Place the excess flies back in the proper stock bottle. Be sure to always transfer etherized flies by use of the paper cone.

Female Drosophila store the sperm which they receive during a mating, and use them to fertilize a large number of eggs over a period of time. It is therefore necessary that the females to be used in an experimental cross be virgins. Females usually do not mate within 12 hours of hatching. If all the adult flies are removed from a culture bottle, the females which emerge during the next 12 hours will no doubt be virgins. Separate the virgin females from the males and keep them in separate culture bottles until ready to use. If the identification is to be made,using the sex comb as the identifying characteristic will be most helpful.

CROSSING DROSOPHILA OF TWO DIFFERENT GENETIC STRAINS

PURPOSE

To learn concepts concerning dominance and recessiveness and correlating these to Mendelian principles.

ACTIVITY MATERIALS

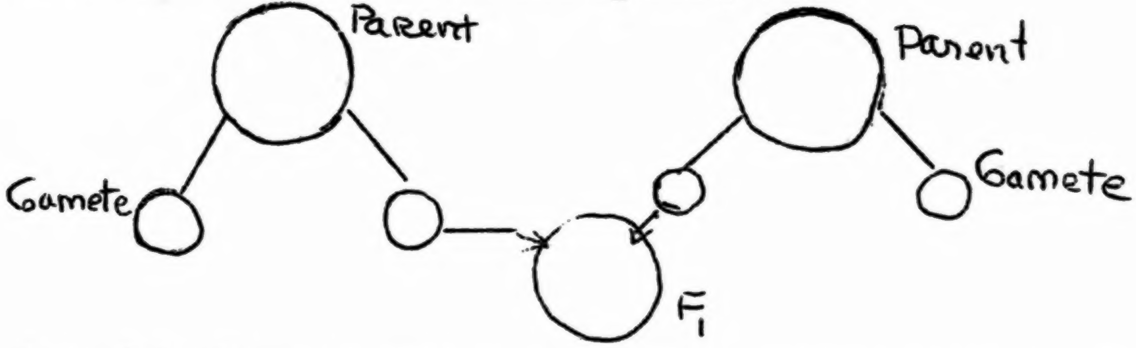
Stock cultures of two different genetic strains of Drosophila
  Virgin females of each genetic strain
New Culture bottles with media
Camel's hair brush
Etherizer
Re-etherizer
Glass plate covered with white sheets of paper or tile squares
Microscope, hand lens or stereomicroscope

WHAT TO DO

Select two or three virgin females of a particular genetic pure strain and place them in a fresh culture bottle. Place an equal number of males of another genetic pure strain in the same culture bottle. Put the cotton stopper back into place and keep the bottle at room temperature (25° C). After seven or eight days remove the original parents from the culture bottles and place them in the morgue. In 10 to 12 days new flies should begin to emerge. Examine the flies after emergence, separating the females into another culture bottle for use in the second generation cross. Record the results in chart given below. Do not count more than 8 days after first fly emerges.

Date of Counting	No. of	Type	No. of	Type
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				

What Mendelian principle does the cross that has just been done illustrate? What is the phenotype in this F_1 generation? Fill in the circles listed below with the genotypes of the parents and also of the F_1 offspring.



Place five or six pairs of F_1 flies in each of three fresh culture bottles. For this mating the females need not be virgins. Do you understand why? Label containers indicating the type of cross and date.

After seven or eight days, remove the parent flies. Place them in the morgue. When the F_2 generation flies emerge, determine how many are of a particular type. Record the information in a data sheet. Continue counting the flies for seven or eight days after the first flies emerge, to a total of 200 if possible. As the flies are counted they may be placed in the morgue.

Date of Count	Number of flies	
	Dom.	Recessive
1,		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		

What are the percentages of the various types of flies in this cross (F_2 generation)? Which Mendelian principle does this cross illustrate? Why were some of the recessive traits hidden in the F_1 generation?

CHROMOSOMAL MAPS

PURPOSE

To learn that genes are found at a particular position (locus) on a specific chromosome

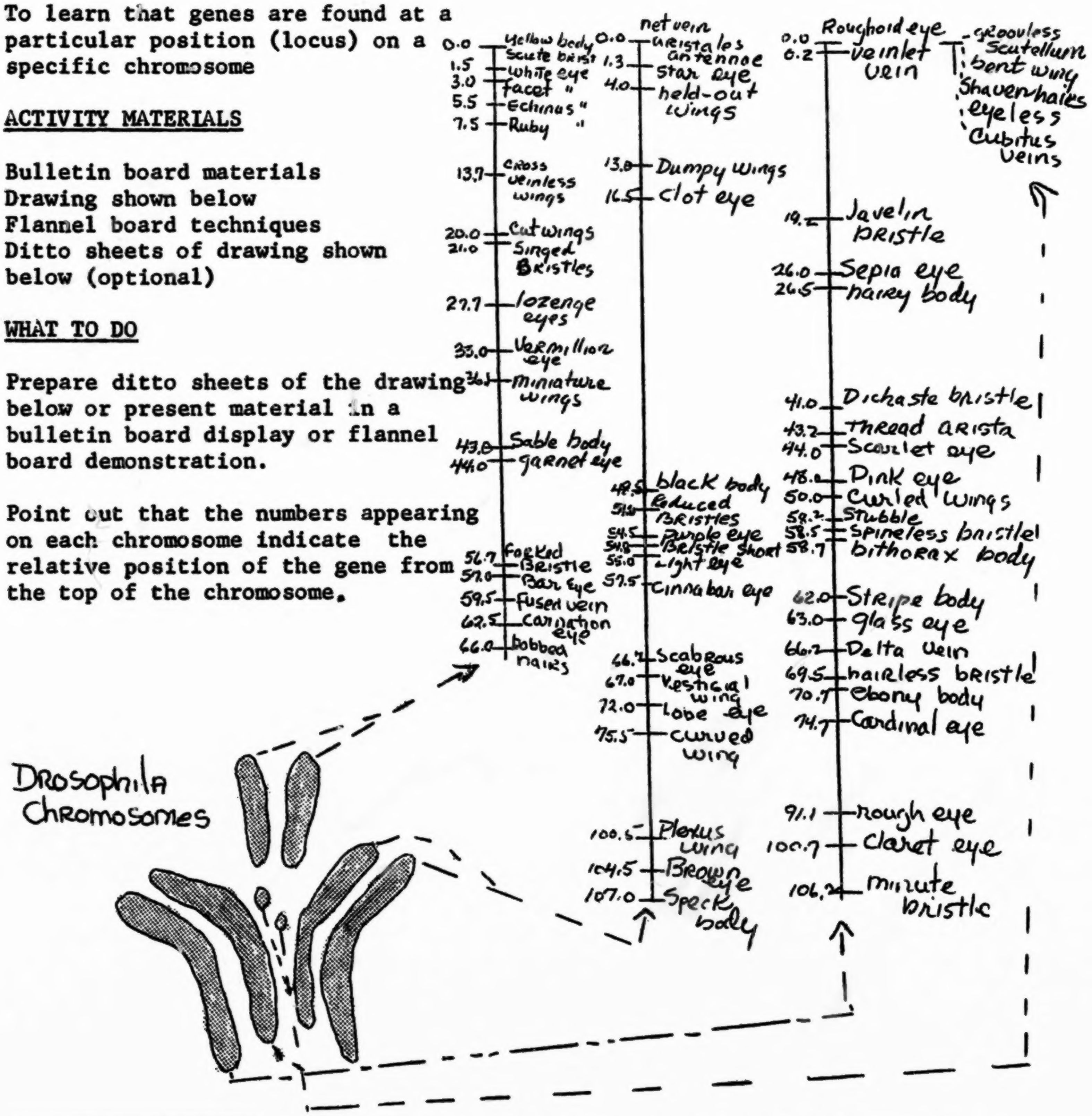
ACTIVITY MATERIALS

Bulletin board materials
Drawing shown below
Flannel board techniques
Ditto sheets of drawing shown below (optional)

WHAT TO DO

Prepare ditto sheets of the drawing below or present material in a bulletin board display or flannel board demonstration.

Point out that the numbers appearing on each chromosome indicate the relative position of the gene from the top of the chromosome.


0.0 Yellow body
Scute brist
1.5 White eye
3.0 facet "
5.5 Echinus "
7.5 Ruby "
13.7 Cross veinless wings
20.0 Cut wings
21.0 Singed Bristles
27.7 lozenge eyes
33.0 Vermillion eye
36.1 miniature wings
43.0 Sable body
44.0 garnet eye
56.7 Forked Bristle
57.0 Bar eye
59.5 Fused vein
62.5 Carnation eye
66.0 bobbed hairs
net vein
0.0 aristales antennae
1.3 Star eye
4.0 held-out wings
13.0 Dumpy wings
16.5 Clot eye
48.5 black body
51.5 Reduced Bristles
54.5 purple eye
54.8 Bristle short
55.0 Light eye
57.5 Cinnabar eye
66.7 Scabrous eye
67.0 Vestigial wing
72.0 Lobe eye
75.5 Curved wing
100.5 Plexus wing
104.5 Brown eye
107.0 Speck body
0.0 Roughoid eye
0.2 veinlet vein
19.2 Javelin bristle
26.0 Sepia eye
26.5 hairy body
41.0 Dichaete bristle
43.2 thread arista
44.0 Scarlet eye
48.0 Pink eye
50.0 Curled wings
58.2 Stubble
58.5 Spineless bristle
58.7 bithorax body
62.0 Stripe body
63.0 glass eye
66.2 Delta vein
69.5 hairless bristle
70.7 ebony body
74.7 Cardinal eye
91.1 rough eye
100.7 Claret eye
106.2 minute bristle
grooveless Scutellum
bent wing
Shaven hairs
eyeless
Cubitus veins
Drosophila Chromosomes

Drawn after Carleen Maley Hutchins *Life's Key: DNA* (Coward-McCann, Inc., New York, 1961) p. 49.

PROBABILITY AND GENETIC RATIOS

PURPOSE

To understand some of the fundamental laws of probability and how they apply to the biology of inheritance.

ACTIVITY MATERIALS

Red beans
White beans
Paper bags

WHAT TO DO

Mix 100 red beans and 100 white beans in a paper bag. Shake the bag thoroughly and draw out one bean at random. Keep a tally of the results in two columns. Add your tally for each column to the sum total for the same columns of the other members of the class. Try to determine the ratio of red beans picked to white beans.

"Probability of single events (p_x) is always a number between 0 and 1. This number is arrived at by dividing the number of favorable outcomes (m) of the event by the number of total possible outcomes (n)."

$$p_x = \frac{m_x}{n_x}$$

"If every possible outcome is a favorable outcome, i.e. $m_x = n_x$ then $p = 1$ or the event x is certain to occur. If no possible outcome is a favorable outcome, then $p_x = 0$ or event x is an impossibility. Probability lies between these two extremes, and the larger the value of p_x, the more certainly may event x be expected to be favorable."

"Probability values are purely theoretical, mathematical measures of expectations, Actual, practical realization of the expectations requires that events occur many times. The more often an event occurs, the more closely will the number of favorable outcomes approach the number predicted by the p value. Thus, probability predictions are most unreliable where they concern one-time occurrences, but become more reliable as the number of occurrences increases."

Mix 100 white beans in a bag with 100 red beans. Shake the bag thoroughly.

(1) Pick out four beans, one at a time and at random. Put the beans back after each draw. Record the number of white and red beans picked. Shake the bag before each drawing.

(2) Pick 10 beans, one at a time and at random. Put the beans back after each draw. Record the number of white and red beans picked. Shake the bag before each drawing.

(3) Pick 20 beans, one at a time and at random. Put the beans back after each draw. Record the number of white and red beans picked.

(4) Now add up the totals for white and red beans from (1), (2), and (3) and record.

Calculate the ratios of white and red beans, separately for the data recorded in (1), (2), (3), and (4). Divide the smaller number (regardless of whether it represents white or red) into the larger number, and carry the division to two decimals. Compare values so obtained.

a. Which of the four comes closest to the theoretical value p_{white}/p_{red}?
b. Which of the tests of the four above gives the most reliable measure of "bean-picking" probability?
c. On the basis of the theoretical consideration $p_x = \frac{m_x}{n_x}$ what is the probability of drawing a white bean and that of drawing a red one(p_{white} and p_{red})?

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*Paul Weisz, Laboratory Manual in the Science of Biology (McGraw-Hill., New York, 1959) p. 137. Used by permission.

STRUCTURE OF DNA and RNA

PURPOSE

To learn and understand the structure of DNA--how it replicates itself; and about the theory of coding.
RNA

ACTIVITY MATERIALS

Cutouts of the figures below (use various colors of construction paper)
Scissors
Flocking paper backing for cutouts
Flannel board

WHAT TO DO

Prepare cutouts of the figures shown. Cut out many copies of each figure. Demonstrate the relationships of Adenine-Thymine Cytosine-Guanine. Build a "flat" DNA molecule.

Demonstrate an RNA molecule. Show the difference between the two molecules of DNA and RNA.

Show the process of replication DNA.

Show the coding idea through groups of A-T and C-G cutouts.

Draw the structural formulas of the various nucleotides on the chalk board to demonstrate that the cutouts are mainly diagrammatic. See figure 2.

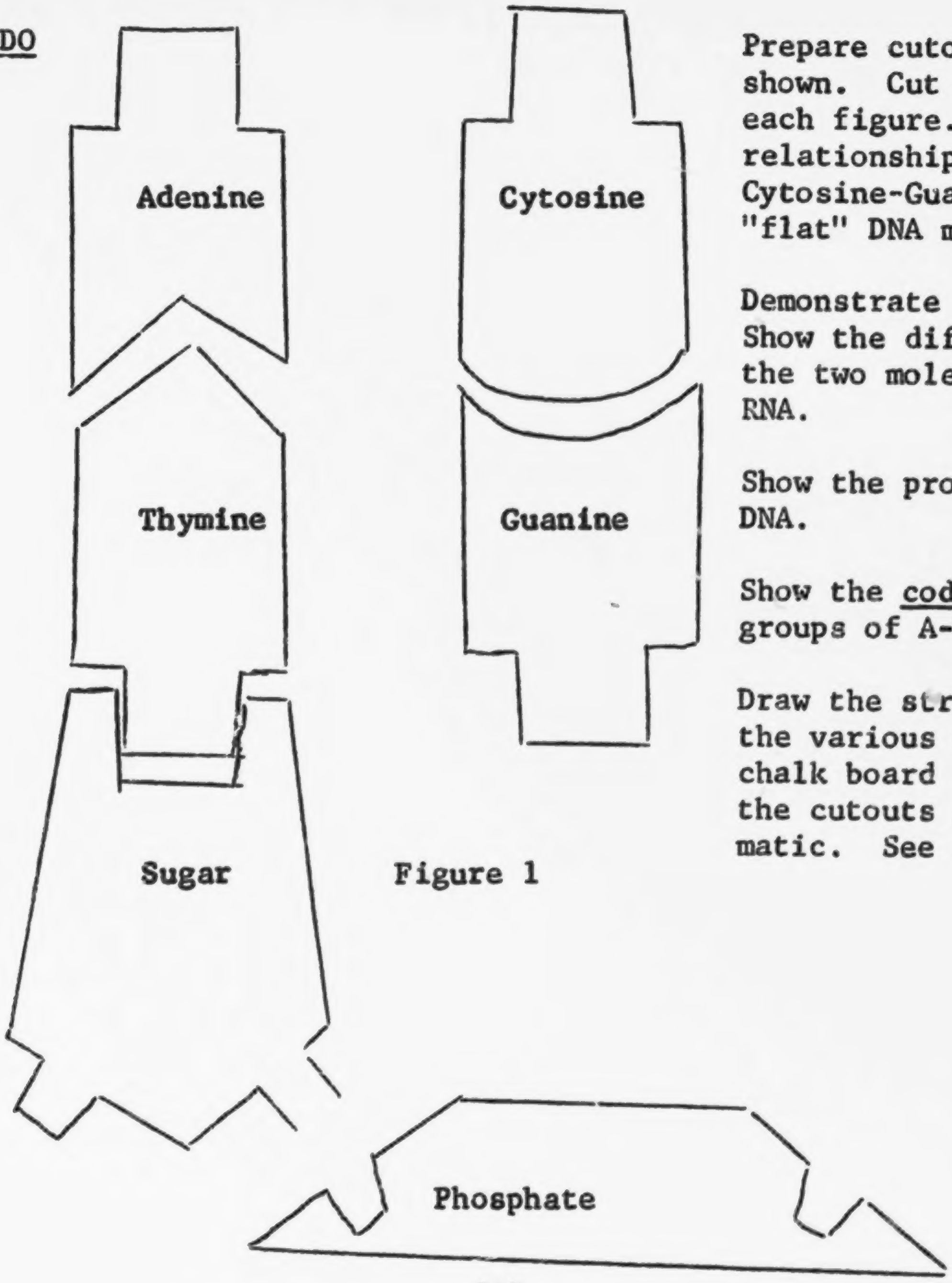


Figure 1

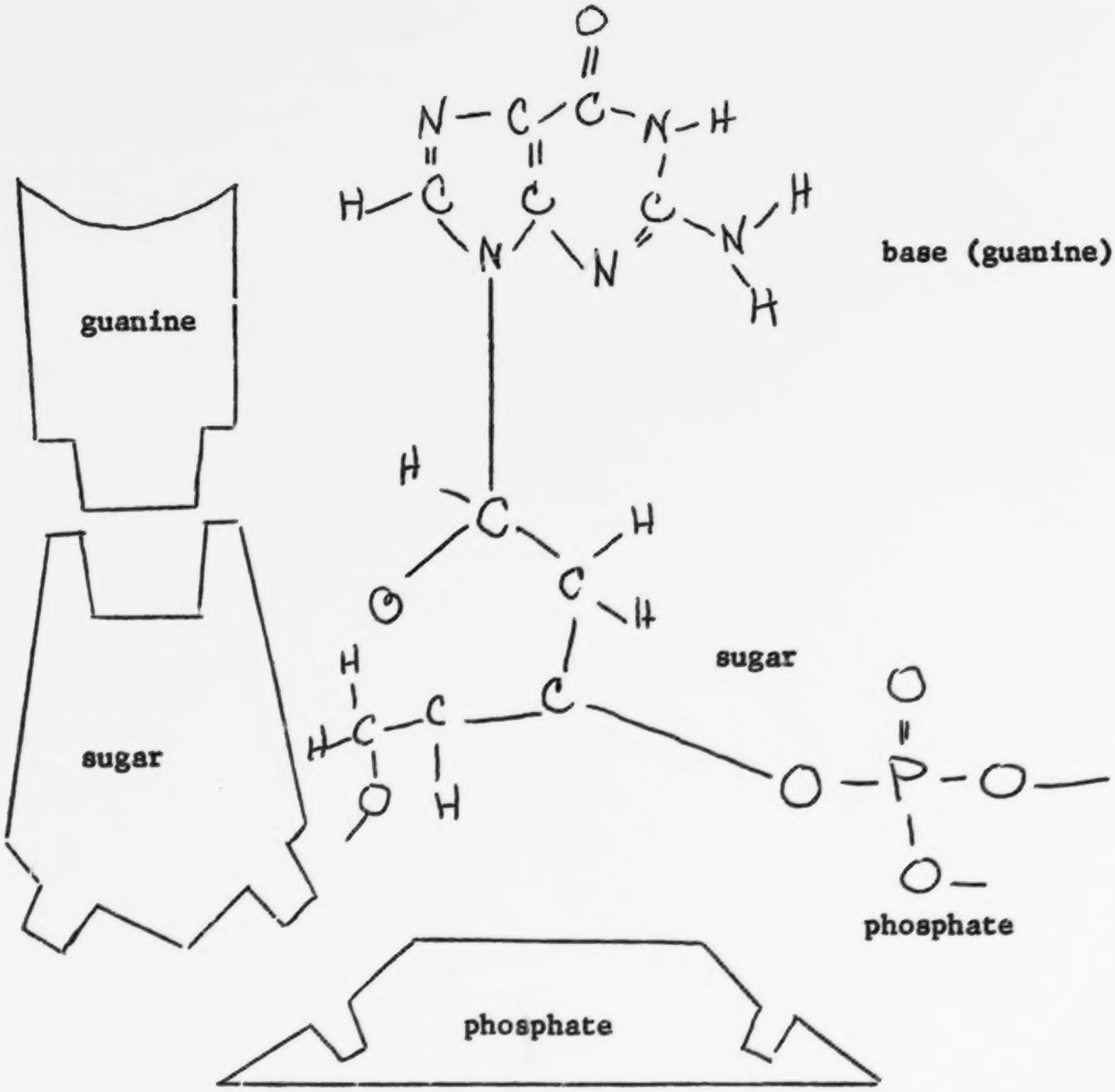

guanine
sugar
phosphate
base (guanine)
sugar
phosphate

Figure 2

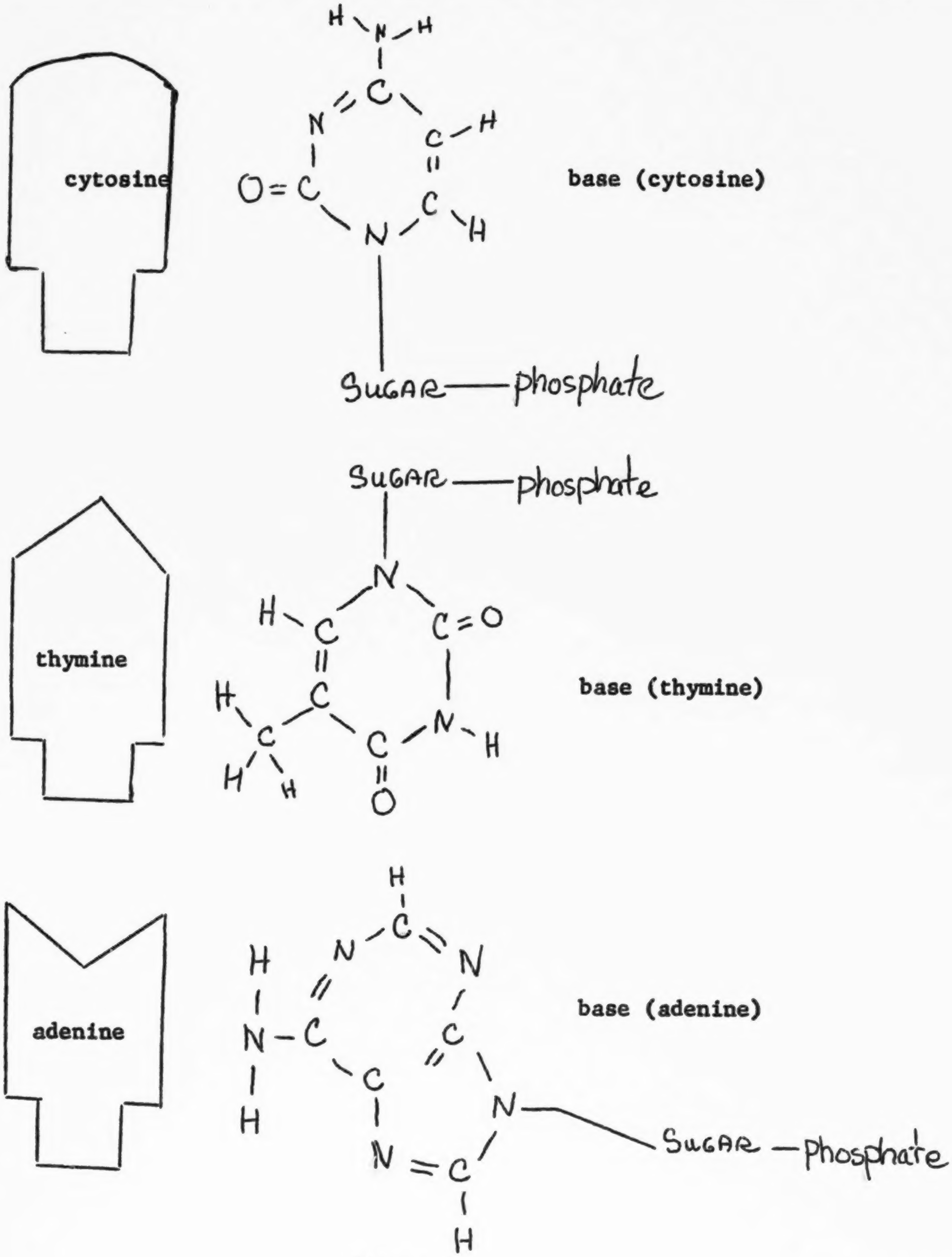
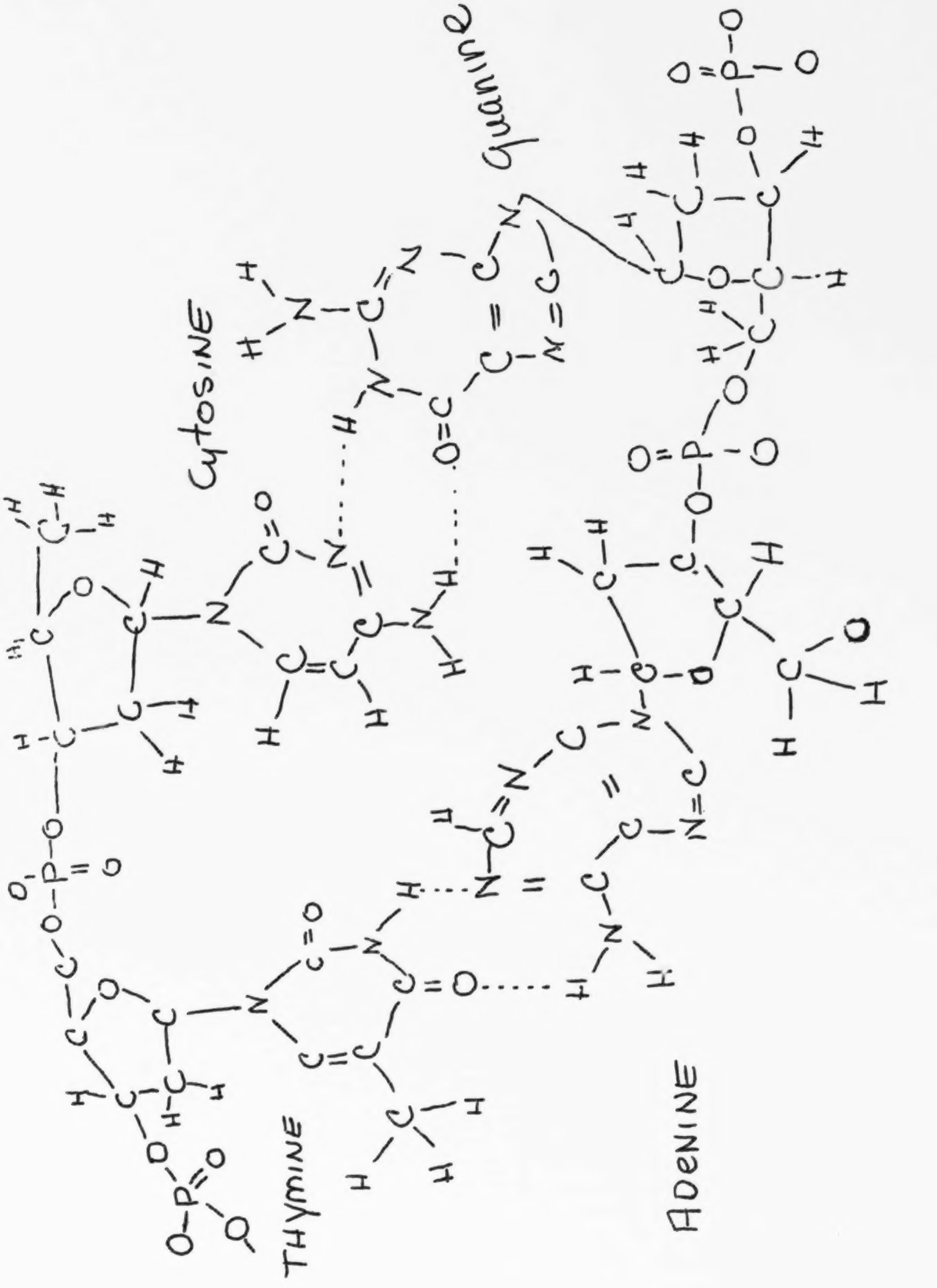

cytosine
SUGAR—phosphate
base (cytosine)
SUGAR—phosphate
thymine
base (thymine)
adenine
base (adenine)
SUGAR —Phosphate

Figure 3


Cytosine
Guanine
Thymine
Adenine

Four Nucleotides

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

CONCEPTS TO CONSIDER

Living organisms on earth today represent the current time segment in a continuing process of change called organic evolution.

Certain assumptions which are more or less generally true, have shaped the interpretation of evolutionary processes. Among these are: (1) Ontogeny recapitulates phylogeny (modern interpretation); (2) Acquired characteristics are not inherited. (3) Complex forms are evolved from less complex ancestors.

Natural selection, acting upon the variations in offspring and upon gene mutations, generation after generation, may result in new varieties or species of organisms.

Gene mutations may result in new traits in one or more individuals in a population. Natural selection usually determines whether such individuals reproduce and pass on the mutant gene.

A mutation is any inherited change not due to segregation or to the normal recombination of unchanged genetic material.

Visible changes in the structure of the chromosome is chromosomal mutation, while invisible changes of the gene is a point mutation and relates to the molecular level of genetic material.

The frequencies of the members of a pair of allelic genes in a population are described by the expansion of a binomial equation $(p + q)^2$ or $p^2 + 2pq + q^2$

Gene mutation is the only known way for a new trait to be added to the gene pool of a population that breeds only within itself.

Any population with a common ancestry is likely to have about the same percentage of each generation showing each hereditary trait (population equilibrium).

The genetic systems of particular populations of organisms tend to stay much the same from generation to generation, sometimes for long periods of time. The genetic systems of organisms carry within themselves the capacity to change.

Survival capacities of a population result from general plasticity of that population. This may be physiological, involving wide tolerances of varying enviromental conditions, or it may be genetic, involving great hereditary variability.

Changes with time in environmental conditions usually force one of three responses upon affected populations: (1) Survival as a result of adaptive responses to the environment (2) Migration to a more suitable environment (3) Eventual extinction due to inability either to adapt or to immigrate.

Speciation, the establishment of a species as a distinct biological entity, depends upon the evolution of reproductively isolating mechanisms, which may be geographic, morphological, psychological, chronological, or ecological.

The evolution of a single ancestral species into a variety of forms which occupy many different habitats is called adaptive radiation..

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

CONCEPTS TO CONSIDER

Many animals inhabiting the same type of habitat have developed similar structures which make them superficially alike. This is convergent evolution.

Adaptations for survival are evident in the color and pattern of plants and animals as well as their structure and physiologic processes, protective mimicry, and warning coloration.

Life on earth had become abundant, as the fossil record shows, about 500 million years ago.

A period of violent change marks the end of one era and the beginning of another in the geologic history of the earth.

The record in rocks shows that violent changes have occurred many times in the past.

Fossils in any particular sedimentary rock are the remains of plants and animals that were living at the time the original sediment was being washed away and deposited.

Change is the rule in the history of living things, even as it is in the history of the individual organism.

From generation to generation, the genetic make-up of any line of organisms does change. Given enough time, the changes become extensive.

The comparisons of the structures of groups of animals and plants show that each organ system has a certain basic pattern that is varied to some extent among the members of a given phylum.

The degree of similarity between enzymes and proteins of closely related organisms is a measure of their evolutionary relationships (biochemical relationships).

The early stages of all vertebrate embryos are remarkably similar.

Evolution occurs most rapidly during times of environmental change.

Evolution does not proceed at the same rate among different types of organisms.

Evolution occurs rapidly when a new group first appears, and then gradually slows down as the group becomes established.

New lines do not evolve from the most advanced and specialized forms already living, but from relatively simple, unspecialized forms.

Evolution is not always from the simple to the complex.

Evolution is characteristic of populations, not of individuals, occurring by mutation, natural selection, recombination, and genetic drift.

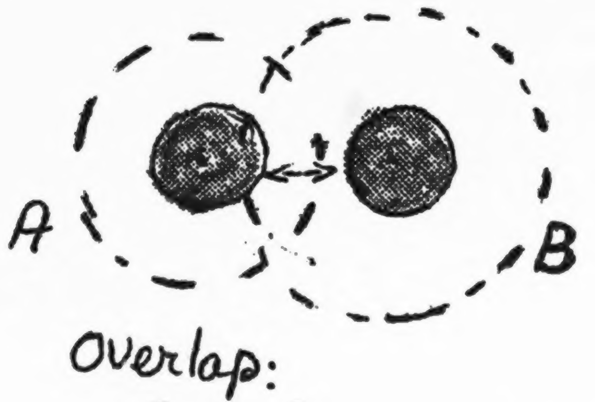
All living men belong to a single species, Homo sapiens.

Man's uniqueness lies in his ability to make tools in accordance with a predetermined plan or pattern.

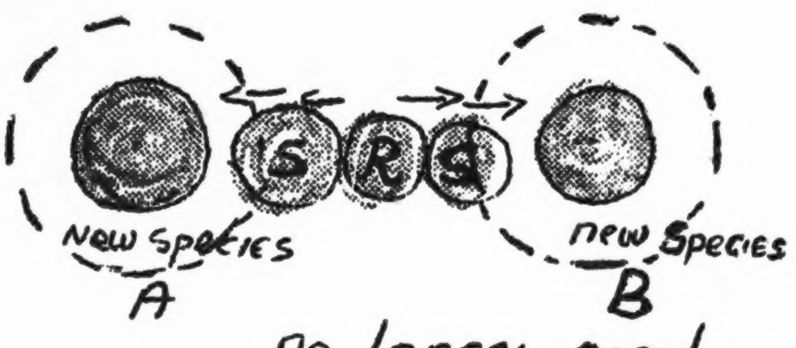
TEACHING APPROACH (Methods and Activities)

Discuss the mechanism of evolution.

- Review the principles and theories learned in unit one, pp. 45-57.
- Discuss theories and principles of early ideas of change in living organisms. Encourage students to keep a time line chart showing the scientists and the development of their ideas as discussion takes place in class. Discuss early scientists such as Aristotle, Redi, Spallanzani, Buffon, LaMarck, Erasmus Darwin, and Charles Lyell. The number of scientists will depend on the time spent in building a good historical background of information.
- Discuss the idea that no two living things are exactly alike. Elicit from students why this is so. Do experiment suggested on p.412 to show variations in living things.
- Illustrate through the study on variations and also through the study of Malthusian principle how Darwin's theory of natural selection can be explained.
- Discuss the life and work of Darwin. Use filmstrip entitled "Great Names in Biology, Charles Darwin" (S-102) found in the blue box collection in the science department.
- Discuss the idea that two individuals may strike upon a similar principle in widely separated places at the same time. Give the example of Wallace and Darwin, Hardy and Weinberg, and others if time allows.
- Discuss the need for understanding the Mendelian principles (work of Gregor Mendel) in interpreting the theory of Natural Selection.
- Discuss genes frequencies in populations. Give an explanation of the Hardy-Weinberg principle of gene frequencies. Students may use PTC taste tests or tongue-rolling trait to do suggested activity on p. 414.
- Give an explanation of the terms gene pool, and gene flow. See suggested activity on p.417 for understanding the term gene pool.
- Give an explanation of speciation. Illustrate as a review how the Grand Canyon (a geographical barrier) caused a species of squirrel to become two species.... the Abert and Kaibab squirrels. Review p. 317 on barriers to dispersion. Students help to prepare a list of other barriers to illustrate how speciation may come about. Give an explanation of biological distance as one of the most effective in this group. Show by simple drawings below how this is so.



Overlap:
Gene flow is Direct



no longer overlap:
Gene flow indirect

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

TEACHING APPROACH (Methods and Activities)

- Describe how artificial selection in plants and animals results in new varieties, breeds, and sometimes new species. Show pictures of Ancon sheep and discuss whether this benefits the animal (as a survival factor) or the sheep breeder.
- Discuss Hugo DeVries and his theory of mutation. With class help prepare a list of mutations in living organisms on the chalk board. Try to include many that have been studied in class. A good start may be Ancon sheep, albino corn, white blaze (or white forelock) in man, seedless trait in oranges, and others.
- Encourage students to decide from this list whether the mutation is useful or harmful from the survival standpoint.
- Discuss how mutant genes may spread in a population. Remember to use terms such as gene pool and gene flow.
- Do activity suggested on p. 418 to show how genes may be mutated. Students help to prepare a list of mutagenic agents on the chalk board. Show pictures of chromosomes that have been irradiated.
- Discuss the work of H.J. Muller and how he was able to cause artificial evolution to take place.
- Discuss polyploidy in plants. Encourage several students to report on the experimentation of Blakeslee and Avery. See activity suggested on p. 421.
- If time allows, encourage several students to report to the class on the harmful effects of radiation on living things. A good source for this is B. Wallace and T. Dobzhansky, Radiation, Genes and Man, Holt-Dryden, 1959.
- Some topics of interest in the effects of radiation on living things may include information on Bikini tests on corn and Muller's fruit fly experiments with X-ray.
- Discuss the difference in radiation of germ cells and somatic cells.
- Discuss Convergence and adaptive radiation. Do activity suggested on p. 423. to help illustrate these principles.
- Encourage student teams to prepare reports on adaptations of animals in the following areas of study: (1) food getting, (2) mimicry, (3) hibernation and aestivation, (4) migration, (5) coloration and camouflage, (6) mating and nesting.
- Assign students to bring in pictures or drawings for their reports to display on the bulletin board.
- Assign students to make a study of migration routes of several interesting animals, which may include butterflies, eels, birds, and vertebrate animals.
- Discuss courtship in animals. Assign several students to make reports on this topic. A good source for reference material is Andrew Meyerrieck's Courtship of Animals, BSCS Pamphlet #3, D.C. Heath and Co., Boston, Mass., 1962.
- Discuss animal navigation. Assign a student to report on this topic. A good source for this is Archie Carr, Guideposts of Animal Navigation, BSCS Pamphlet #1, D.C. Heath Co., Boston, Mass., 1962.
- Discuss the topic Biological clocks. A good source for reference is Frank Brown, Jr., Biological Clocks, BSCS Pamphlet #2, D.C. Heath Co., Boston, Mass., 1962.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

Discuss evidences of evolution

- Discuss the extinction and replacement theory
- Assign students to read about conditions that existed to cause dinosaurs to become extinct.
- Display several different types of vertebrate embryos in the classroom
- Assign students to prepare a diagram that shows stages of embryology of a fish, tortoise, and chick (or any other combination of vertebrate animals).
- Students use their diagram to write a short paragraph on how comparative embryology is used to support the theory of evolution
- Assign several student teams to plant a variety of seeds, such as corn, wheat, oats, peas, radishes and beans. Students examine seedlings of plants and give an explanation of the similarities. Assign students to make a drawing of comparative plant embryology as they make their examinations of the seedlings.
- Review pp. 142-43 to show that studying homologous structures is another means of support for the theory of evolution.
- Discuss and point out vestigial organs in man and other animals. Assign students to locate at least five vestigial organs of animals and give relationships of these organs' previous function (vestigial organs not previously discussed in class).
- Review activity suggested on p. 425. Discuss industrial melanism and how this is more evidence in support of the theory of evolution. Students do this activity as homework.
- Encourage several student teams to do activity suggested on p.429 to show the effect of natural selection on a population in the study of sickle cell-anemia.
- Discuss the effect ot D.D.T. on the evolution of certain insects and also antibiotics on the evolution of certain bacteria. Encourage some interested student to make a report to the class on Rachel Carson's book The Silent Spring.
- Assign students to prepare a bulletin board entitled GEOLOGIC TIME CLOCK AND FOSSILS
- Assign student teams to do activity on p. 437 to show how fossils have been formed
- Students are encouraged to bring in fossils and models of fossils that they may have collected to display in the classroom.
- Prepare a display of pictures of prehistoric animals and plants.
- Assign students to make short reports on a variety of prehistoric animals and plants.
- Encourage students to keep a time line of the emergence of various animals and plants on a geologic time table.

- Assign students to report on various scientists who were involved in bringing about the study of paleontology. Include such names as Charles Lyell, Jean Lamarck, George Cuvier, Alexandre Brongniart, William Smith, Charles Darwin, Eugene Dubois, Davidson Black, W. C. Pei, von Koenigswald, Franz Weidenreich, Raymond Dart, Robert Broom, and Louis Leakey. A fine source for these reports is the book by Ruth Moore, Evolution, Time, Inc., 1962, New York, pp. 109-172.
- Play the transcription entitled "Great Scientists Speak." Play the bands that have G. G. Simpson's talk about paleontology and Julian Huxley's talk on facts about evolution.

Discuss changes in primates.

- Assign students to prepare a drawing showing the differences in skulls of the various prehistoric men.
- Students prepare a chart showing the differences and changes that took place in man. If time allows, a column devoted to cultural change should be included showing uses of tools.
- Discuss the various finds made by W. C. Pei, von Koenigswald, Weidenreich, R. Dart, R. Broom, and most recently of Louis Leakey.
- Assign students to prepare a chart showing the primate tree. A good source for this is Ruth Moore's book, Evolution, Time, Inc., New York, 1962, pp. 156-157, and also Margery and Lorus Milne's book Biotic World and Man, Prentice-Hall, Englewood Cliffs, New Jersey, 1958, p. 455.

DEPTH PROBE

- HOW DO PLANTS AND ANIMALS VARY? pp. 417 (Average Student Basic Activity)--To understand and learn concepts pertaining to variation within a species and how these variations are distributed according to a normal curve. Students work in pairs or teams.

- GENE FREQUENCIES IN A POPULATION STUDY, p. 414 (Average Student Basic Activity)--To understand the mechanics of the Hardy-Weinberg principle in the study of population genetics. Students work in teams and individually.

- GENE POOL AND GENETIC DRIFT, p. 417 (Average Student Basic Activity)--To understand the effect of small population size on allele frequency and homozygosis. Students work in pairs or teams.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

- RADIATION EFFECTS ON THE GERMINATION AND GROWTH OF SEEDS, p. 418 (Average Student Basic Activity--Optional)--To study the effects of X-irradiation upon the germination and growth of seeds and to determine the range of abnormalities caused by changes in genetic structure (through mutations). Students work in teams.
- POLYPLOIDY, pp. 421-422 (More Able Student Basic Activity--Optional)--To illustrate that certain factors may produce extra sets of chromosomes. Students work in teams.
- ADAPTIVE RADIATION AND CONVERGENT EVOLUTION, pp. 423-424 (Average Student Basic Activity)--To illustrate that no two species can occupy the same ecological niche. The results of slight differences within a given species may cause divergence through the process of natural selection. To contrast the principle that similar environments may produce similar changes in unrelated organisms. Students work individually--may also be used as a teacher demonstration.
- POPULATION AND NATURAL SELECTION, pp. 425-427 (Average Student Basic Activity)--To understand what effect natural selection may produce on the gene frequencies (that is, the commoness and rarity of particular alleles) in a population. Students work individually.
- SICKLE CELLS AND EVOLUTION, pp. 429-432 (More Able Student Basic Activity)--To understand how sickle cells show the mechanics of change in blood cell shapes in certain parts of the world. Students work individually and in pairs.
- COMPARISON OF FORM TO SHOW CHANGE, pp. 433-436 (Average Student Basic Activity) To learn that the historical development of a group of living things may be studied through change of a single characteristic within that group and by comparisons of the changes that have taken place. Students work individually or in pairs.
- HOW FOSSILS ARE FORMED, p. 437 (Average Student Basic Activity)--To illustrate various methods of how animals and plants have been preserved over the centuries. Teacher demonstration or students work in teams.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

"TOOLS" FOR EXTENDING CONCEPTS

- Plan to show films
  "Adaptive Radiation, The Molluscs"

- Plan to show filmstrips
  "Great Names in Biology" Set 4 - "Charles Darwin" S-102 (Science Department blue box collection).
  "Age of Mammals" S-130
  "Prehistoric Life" S-3
  "Reptiles Inherit the Earth" S-129

- Exhibits
  "Protective Mimicry" - Set 1

- Encourage an interested student to read about artificial selection in breeding of cattle. Student reports to the class about breeds of cattle that have been improved upon such as Santa Gertrudis breed.
- Assign a student team to observe the lethal action of albinism in corn or tobacco plants. Seeds may be obtained on the consummable supply list. Plant seeds according to directions on package. Seedlings should develop within twelve days.
- Encourage a student to try to raise albino corn to maturity.
- Encourage an interested student to study the survival value of protective coloration of different animals. Some models could be twig--its mimic, walking stick; another model, monarch butterfly--its mimic, viceroy butterfly.
- Investigate animals in their natural background. Assign students to bring in a variety of color photographs to show how protective coloration is able to protect the animal.
- Assign a student to study and report to the class about warning coloration of animals.
- Encourage a highly interested student to study and do research work on how to develop a resistant strain of bacteria. Try using 25 mg of Streptomycin per liter of agar to see if any resistant strains will survive. (Escherichia coli bacteria culture should be used with extreme caution, since all bacteria are potentially dangerous. Use sterile techniques with all species.)
- Display a variety of bird beaks and feet. Assign student groups to make observations on how the animals have become adapted to their environment.
- Encourage some student to report on radio-active dating and how it has been used in telling the age of fossils.
- Assign some students to do a blood typing experiment.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

"TOOLS" FOR EXTENDING CONCEPTS

- Encourage a student to find examples of genetic drift in certain populations and to report on them to the class.
- Discuss the difference between random matings and non-random matings and the effect this would have on the gene frequencies according to the Hardy-Weinberg principle.
- Discuss Biological distance as an effective factor in forming of two new species.
- Discuss adaptive radiation in marsupial animals of Australia.
- Encourage a student to read and report on "Darwin"s Finches" by David Lack, Scientific American, April 1953.
- Encourage some student to read about "Sickle Cells and Evolution" by A.C. Allison, Scientific American, Vol. 195, 1956.
- Assign a student team to prepare a bulletin board showing the EVOLUTION OF THE HORSE, ELEPHANT, AND CAMEL.
- Observe an aquarium with a group of neon tetra fish. Assign a student to report on the social behavior of these fish. Is there a leader?
- Encourage a student to prepare giant salivary chromosomes of a fruit fly for microscopic examination.
- Encourage a student to make skeleton preparations for a fish, frog, chick, and rat. Student makes comparisons of skeletal material and correlates relatedness or unrelatedness.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

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UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

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UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

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UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

HOW DO PLANTS AND ANIMALS VARY?

PURPOSE

To understand and learn concepts pertaining to variation within a species and how these variations are distributed according to a normal curve.

ACTIVITY MATERIALS

Construction paper
Several hundred Scallop shells
Several hundred sunflower seeds
Calipers
Several hundred lima beans
Graph paper
Bottles
Flowers, such as daisies, dandelions, or asters

WHAT TO DO

Select one or two activities from the following:

A. Students make a cutout of their left hand on construction paper. Arrange hand cutouts on the bulletin board or flannel board according to size. Plot a curve showing the number of small hands, medium size hands, and large hands. What relationship is there between male and female hand cutouts?

B. Tabulate the number of "ray" flowers in the head of a daisy, aster, or dandelion. Tabulate the ray flowers in a large number of heads of a single species. Make a graph of the results.

C. Measure the length of three hundred lima beans to the nearest tenth of a centimeter. Tabulate information and make a graph of results. Place similar length beans in bottles to show their distribution. Make a graph of results.

D. Collect one hundred Scallop shells and place them in groups according to the number of grooves per shell. Plot a curve indicating the distribution of variation for this characteristic.

E. Measure the cephalic index of a group of students in the classroom. Cephlalic index is

$$= \frac{\text{width of head}}{\text{length of head}} \times 100$$

E. Measure the cephalic index of a group of students in the classroom. An individual whose index is less than 75 is considered longheaded (dolichocephalic). 75 and 78 is considered, medium-headed (mesocephalic). 80 or above is wide-headed (brachcephalic). Make a graph of the results. Decide which of the three groups is most predominant.

$$\text{Cephalic index} = \frac{\text{width of head}}{\text{length of head}} \times 100$$

If commercially made calipers are not available, prepare the following: Fasten two sticks of wood at right angles to a meter stick. The first stick should be fixed permanently at the "0" end. The second stick should be arranged so it can slide along the scale to indicate the distance between it and the first stick.

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

GENE FREQUENCIES IN A POPULATION STUDY

PURPOSE

To understand the mechanics of the Hardy-Weinberg principle in the study of population genetics

ACTIVITY MATERIALS

Ditto information of material written below

WHAT TO DO

There is probably not much likelihood that two students belonging to the same family will be members of the same class in school. Therefore, let us begin by determining the frequency of tongue-rolling among the members of our class---that should give us a small but fairly random sample of our local population. From pictures in your textbook or on the bulletin board, familiarize yourself with the tongue-rolling trait. Determine whether you can do this. Most persons find that either it can be done easily, without any need to practice, or else it cannot be done at all after any amount of trying. Record the results in your notes. When everyone has done this, pool the results of the class and record them in the chart below.

Number of tongue-rollers	Number of non-rollers	Total	Percentage of rollers

Gather more information, determine the number of tongue-rollers and non-rollers in your own immediate family (parents, brothers, and sisters). Record the results. When these are reported back to the class, and all the information from all the families is recorded as before, decide from the information whether the percentage is different than for the class itself. Determine from the data whether tongue rolling is dominant or recessive.

Adapted from High School Biology, Green Version - The Laboratory, Part Three, Exercise 15.13, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

Gather data on tongue-rolling from five neighbors, no two of them belonging to the same family. If you live near another member of this class, decide which of the neighbors to sample so that you do not sample the same persons. Remember, do not get information for this sampling from more than one person per family. Record the data from the information given in class on this sampling. Is it the same, or quite different from our previous samplings? Add together the class data and the neighbor data but do not add in the family data. Calculate the percentage of tongue-rolling in this new total.

According to the Hardy-Weinberg principle, if the population sampled is in a genetic equilibrium with respect to the trait being studied, then the ratio of genotypes for a simple two-allele difference will be p^2: 2 pq: q^2 where p and q are respective frequencies of the dominant and recessive alleles. If you have determined whether tongue-rolling is dominant or recessive, note the frequency in the random sample of the population of the recessive trait. This is equal to q^2. Take the square root of this percentage to find q (For example, if the frequency of the trait is 36% 0.36, the square root of it will be 0.60, that is, 60%. If the frequency of the trait is 16% or 0.16, its square root is 0.40 or 40%). Is the frequency of the recessive allele larger or smaller than the frequency of the recessive trait?

Having determined the value of q, the recessive allele, now find the value of p. If there are only two alleles, p + q = 100%, or 1.00. Therefore, p = 1.00 - q. For example, if q = 1 = 0.60, p = 0.40. If q = 0.30, p = 0.70.

Now substitute the values of p and q in the binomial expression, $p^2 + 2pq + q^2$ You already know the frequency of the recessive trait, which is q^2. Find the frequency in your population of the homozygous dominant type (p^2) and the frequency of the heterozygous type (2pq). What is the ratio of the homozygous dominant type, that is, p^2 : 2pq?

In a single family in which two heterozygous persons marry, the children are expected to be, according to simple Mendelian laws, three dominant type to one of the recessive type. In the population, is the ratio of the dominant persons (p^2 + 2pq) to the recessive persons (q^2) a 3/4 : 1/4 ratio , or not? Explain.

We may also calculate the probability of marriages between persons of the three genotypes. Is choice of mates affected by the trait, in the case of tongue-rolling? If choice of mates is not affected by the trait, the probability of any particular mating is the product of the frequencies of male with the specified genotype and females with the specified genotype.

For example, suppose some population is made up of 16% homozygous brown-eyed persons, 48% heterozygous for eye color, and 36% homozygous blue-eyed persons. Are these distributed according to the Hardy-Weinberg principle? If eye color does not affect choice of mates, the probability of a marriage between a blue-eyed person and a brown-eyed person would be double

$$(0.16 + 0.48) \times 0.36 = 2 \times 0.64 \times 0.36 = 0.4608 \text{ or about } 46\%$$

of all the marriages. Why double? Because blue-eyed by brown-eyed matings could be either blue-eyed female by brown-eyed male or blue-eyed male by brown-eyed female. Now calculate how often you would expect a tongue-roller to marry a non-roller in your population. Other frequencies of matings may also be predicted.

GENE POOL AND GENETIC DRIFT (SEWALL WRIGHT EFFECT)

PURPOSE

To understand the effect of small population size on allele frequency and homozygosis

ACTIVITY MATERIALS

Red beans and white beans
paper bags

WHAT TO DO

Students work in teams. Count out 10 red beans and ten white beans and place them in a single paper bag. One student draws two beans at a time from the bag (without looking). The other student marks information in chart shown in figure 1. If two red beans are drawn at one time place a tally mark in column marked AA; if a red and white bean are drawn place a tally mark in Aa column; and if a two white beans are drawn at one time place a tally mark in column marked aa.

For each tally mark in AA column, place four red beans back into the empty bag. For each tally mark appearing in the Aa column, place two red and two white beans into the bag. For each tally mark appearing in the aa column, place four white beans into the bag. Now draw ten pairs of beans in the same manner as described above. Place tally marks in the appropriate columns for generation. After ten pairs have been drawn, empty the bag and repeat, using information in second generation. Fill bag with beans according to directions given for tally marks in this paragraph. Draw ten pairs of beans again, keeping a tally for generation 3. Empty bag and repeat as directed. Continue this for about ten generations. Continue until there are only red or white beans remaining. At this time one allele is fixed and the other eliminated from the population. Fill in the blanks for p and q for each generation. Do all teams take the same number of generations to reach fixation of an allele? If a large population were broken up into a number of isolated small populations, can you see how genetic drift could cause them to become genetically distinct from each other?

RADIATION EFFECTS ON THE GERMINATION AND GROWTH OF SEEDS

PURPOSE

To study the effects of X-irradiation upon the germination and growth of seeds and to determine the range of abnormalities caused by changes in genetic structure.

ACTIVITY MATERIALS

- Seeds of oats, sunflower, or corn
- Dissecting needles
- Bunsen Burner
- Metric rulers
- Seed flats (or paper cups may be used instead)
- Vermiculite or sawdust
- Blotting paper (paper towels)
- Petri Dishes

WHAT TO DO

Note to Teacher: Teacher arranges to take all seeds for entire class to a dentist's office or to a hospital to be irradiated. Irradiate one-third of all the seeds for 32 seconds, another third of the seeds for 16 seconds, and the last third for 8 seconds. If the irradiation is to be done in a hospital, use the following dosages: first third of all seeds for 28,000 r, second third of all seeds for 14,000 r, and the last third of all the seeds for 7,000 r.

After irradiation of the seeds, each team is given a definite number of seeds of a particular radiation dosage. Five seeds of this dosage are placed in between two pieces of moist filter paper, covered, and put in a dark place. Dish should be labeled with the team's symbol and type of seed. Be sure that the filter paper is kept moist everyday.

Plant fifteen seeds of the particular dosage in paper cups or seed flats. The seeds should be planted about 1 cm deep and about 2.5 cm apart in neat rows. Label each row or section of the seed flat with the team symbol and type of seed. If paper cups are being used, label the team symbol and type of seed on each cup. Water the seeds thoroughly, but do not overwater, and place the cups or seed flats in filtered sunlight. One team will be given 20 seeds that are non-irradiated to be planted as above.

Observe the seed flat everyday. Record the height in centimeters of each plant for a period of three weeks after germination. Record any death with a "D". Observe the petri dish with the five seeds everyday. Make a tally of the number of seeds that have germinated. Fill in the chart shown on the next page.

Adapted from High School Biology, Green Version - The Laboratory, Part Two, Exercise 12.1, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

Chart 1

Team	Number of seeds germinated	Per cent of seeds germinated	Comments
Oats			
7,000 r (8 sec)			
14,000 r (16 sec)			
28,000 r (32 sec)			
Corn			
7,000 r (8 sec)			
14,000 r (16 sec)			
28,000 r (32 sec)			
Sunflower			
7,000 r (8 sec)			
14,000 r (16 sec)			
28,000 r (32 sec)			

After filling in the data on chart 1, chart 2, and chart 3, try to correlate the amount of radiation to the rate of growth. Is there any correlation between the variations (if any) in the appearance of the plants? Correlate the amount of radiation to the rate of germination.

	Height in cm															
	1st Week					2nd Week					3rd Week					
Plant	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Other Comments
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																

	Oats	Corn	Sunflower
Non-irradiated			
Group I			
Group II			
Group III			

SUMMARY TABLE

POLYPLOIDY

PURPOSE

To illustrate that certain factors may produce extra sets of chromosomes.

ACTIVITY MATERIALS

Colchicine
Onion bulbs
Glass slides and cover slips
Microscope
Razor blade
Bunsen burner
Aceto-carmine stain
Paper towels
Pyrex watch glass
Beakers

WHAT TO DO

Select a fresh, firm onion bulb and cut off the old, dried roots close to the base of the bulb. Use an appropriate size beaker to support the onion on the rim just in the water (or use toothpicks, as suggested on p. 347). Place two onion bulbs in two beakers of fresh water and two onion bulbs in two beakers of a 0.03% solution of colchicine. Using a wax pencil, mark each of the four beakers containing water or colchicine. Place the beakers and their onion bulbs in subdued light for several days and make daily observations for new white roots to appear.

When new roots appear in beakers of water and are about 1½ to 2½ cm in length, cut the root tips near the lower, denser part of the root and place in a pyrex watch glass with about two ml of aceto-carmine stain. Gently heat the stain and root tips, without allowing them to boil, for about five minutes.

Remove a root tip and place it on a clean slide in a fresh drop of aceto-carmine stain. Cut off the very tip of the root and mince with a razor blade on the slide. Cover these pieces with a cover slip and gently but firmly squash the cover slip against the root tip pieces without crushing the cover slip. Now observe the slide under low power and high power of the microscope. Make sketches of the mitotic figures and count the number of chromosomes present in each cell.

Adapted from High School Biology, Green Version - The Laboratory, Part Three, Exercise 15.3, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

Follow the same procedure for making preparations of root tips that have been growing in colchicine.

Is there any difference in the treated root tips on the process of mitosis? Can you distinguish the number of stages in those treated in colchicine? In those untreated? Is there any stage that seems to be more common in untreated root tips?

More common in the treated root tips?

ADAPTIVE RADIATION AND CONVERGENT EVOLUTION

PURPOSE

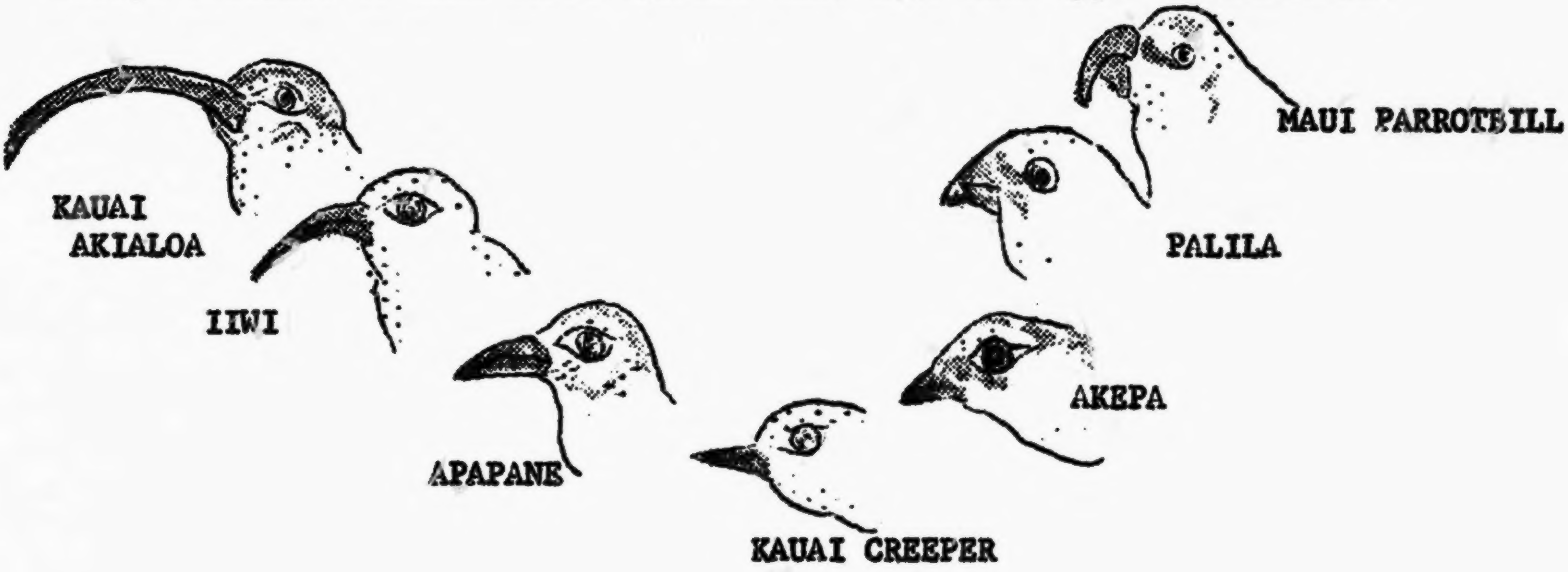
To illustrate that no two species can occupy the same ecological niche, thus resulting in slight differences in which the process of natural selection causes divergence.

ACTIVITY MATERIALS

Pictures or cutouts of animals shown below or other animals that will illustrate the same principle
Bulletin board or flannel board

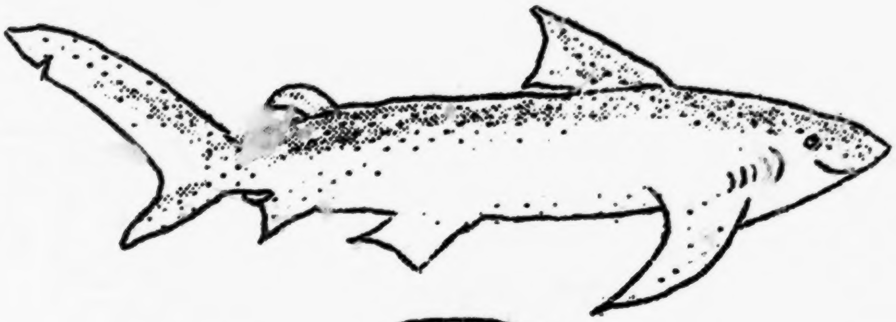
WHAT TO DO

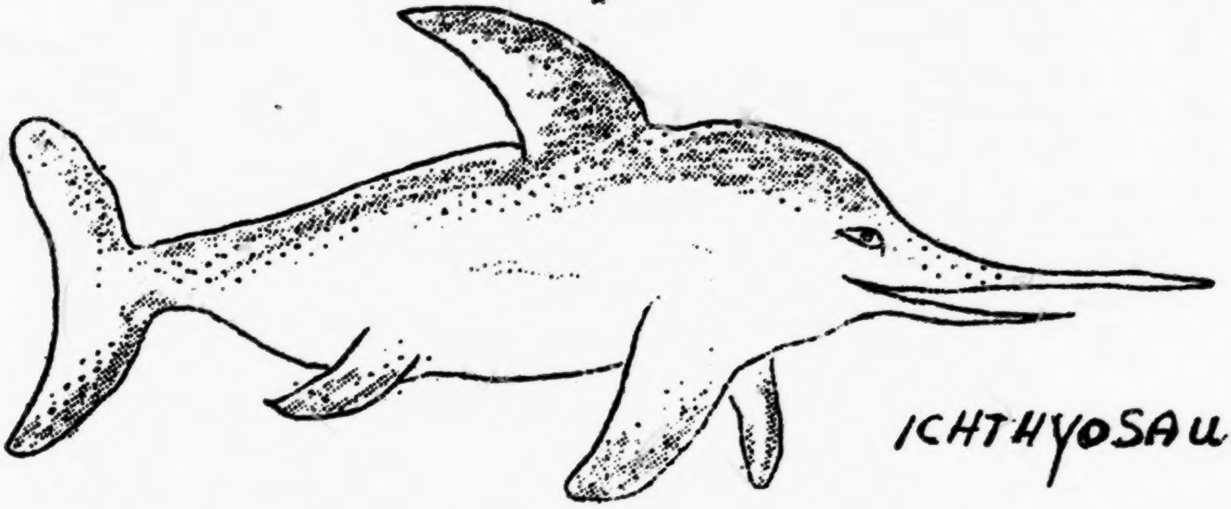
Prepare cutouts or pictures of the birds shown below (or other animals). Review Gause's Principle (as described on p. 299). Assign students to observe slight degrees of differences in birds and to decide why these differences exist. Make a chart on the chalk board of the differences and the reasons for these differences. Students write a short paragraph to explain adaptive radiation. Assign students to find other animals that show this type of radiation.

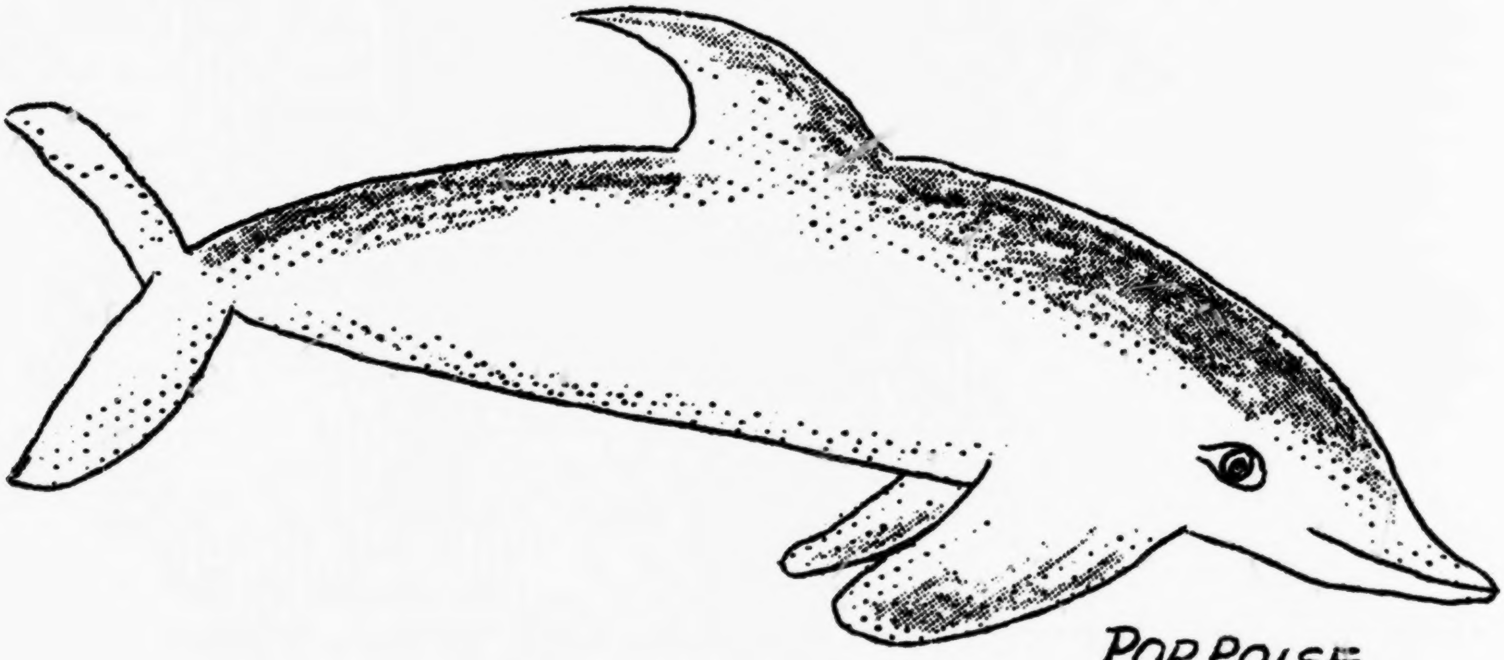


Drawn After High School Biology, BSCS Green Version p. 311 (Figure 10-12)
Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

Give a brief explanation of convergent evolution. Use cutouts shown below and prepare other examples to explain this principle. Explain the difference between adaptive radiation and convergent evolution.







UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

POPULATIONS AND NATURAL SELECTION

PURPOSE

To understand what effect natural selection may produce on the gene frequencies (that is, the commoness and rarity of particular alleles) in a population.

ACTIVITY MATERIALS

A large poster of diagram (figure 1)
A ditto sheet of information as given below
Flannel board cutouts of diagram (optional)

WHAT TO DO

Gene Frequencies in Populations

To make the situation just as simple as possible, let us first consider an imaginary population of moths in which there is a constant size population and a constant environment. In this species of moth there are two hereditary phenotypes--one black in color, the other white, speckled with black. Crosses have already shown us that black (W) is dominant over speckled white (w), and that the genes determining this difference are a simple pair of alleles.

Assume that the population consists of 1000 moths, with equal numbers of males and females, and that 500 are homozygous black (WW) and 500 are homozygous white speckled with black (ww). Diagram the results of random mating in this population. Remember that black can mate with black as well as with speckled white, and that white can mate with white as well as with black. Will a black male have an equal chance of mating with a black female and with a white female? Will a white female have an equal chance of mating with a black male and with a white male? Your diagram should show four possible kinds of matings. Now express these four kinds of matings in terms of genotypes, ignoring sex; for example WW X ww. Are any of the four matings the same? Beside each type of mating, place the genotypes of all the kinds of offspring that cross can produce. Does any cross produce more than one kind of offspring? What will be the proportions of black and white moths in the next generation, if we assume that it is also composed of just 1000 moths and that every type of mating contributes to it just as much as every other type of mating? Is this proportion of black and white moths the same as that in the first generation?

Adapted from High School Biology, Green Version - The Laboratory, Part Three, Exercise 16.1, BSCS, 1961. Permission granted by Biological Sciences Curriculum Study, Boulder, Colorado.

Now consider the frequencies of the two alleles, W and w, in this population. What were the proportions (percentages) of each to start with? What are they in the second generation? Is the proportion the same as in the first generation, or is it different?

You can now carry the calculation to still another generation by mating every genotype with every other genotype in proportion to their frequencies. But this gets complicated and tedious. You can get the same result by a "gene pool" method, if you compute the frequencies in the population of all the kinds of gametes relating to the character under study, and then assume random combination of these gametes. For example, if the frequency of W in the population is .5 and of w is .5, then the sperms will be half carriers of W and half carriers of w; and the same will be true of the eggs.

Hence the result will be

$.5\,W + .5\,w$ sperms

$.5\,W + .5\,w$ eggs

Product $.25\,WW + .50\,Ww + .25\,ww$ Offspring generation

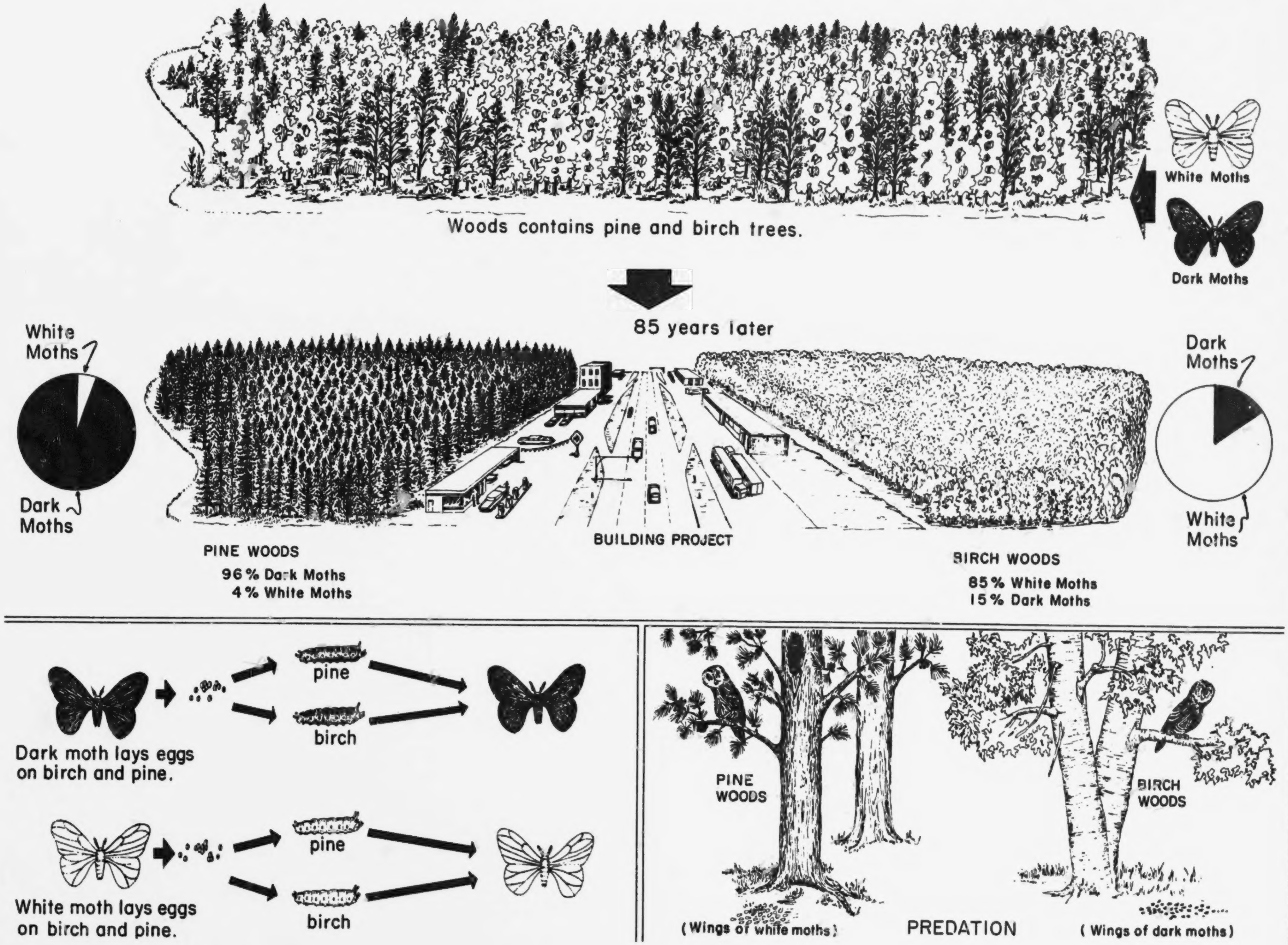
What will be the frequencies of W and w in the gametes of this new generation? Will they be the same as before or different?

It is important to see whether the conclusions we have drawn will follow regardless of what the original frequencies of W and w might be. Go back to the beginning and repeat the calculations, but this time assume that there are 400 homozygous black and 600 homozygous white moths in the population. What do you find? Try to state this general conclusion in a single sentence.

Natural selection

Examine the pictures on p. 428 and state what change took place in the environment of the original moth population. What change was produced in the moth population as the result of this environmental change? Cite evidence which indicates that the change in the moth population is not simply a phenotypic effect of the environment, but is really hereditary. Do you think that it was a change in the reproductive capacity of the two kinds of moths, or that it was a change in the environmental resistance to success in life that resulted in the separation of the original homogeneous moth population into two distinct subpopulations?

What has happened to the frequency of the allele for white color in the moth population now living in the pine woods? If the environments change over a period of time, what must happen to populations if they are to survive? Could a change in reproductive capacity ever offset the force of natural selection acting differently on two types such as the black and white moths?


White Moths
Dark Moths
Woods contains pine and birch trees.
85 years later
White Moths
Dark Moths
Dark Moths
White Moths
PINE WOODS
96% Dark Moths
4% White Moths
BUILDING PROJECT
BIRCH WOODS
85% White Moths
15% Dark Moths
pine
birch
Dark moth lays eggs on birch and pine.
pine
birch
White moth lays eggs on birch and pine.
PINE WOODS
BIRCH WOODS
(Wings of white moths)
PREDATION
(Wings of dark moths)

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SICKLE CELLS AND EVOLUTION

PURPOSE

To understand how sickle cells show the mechanics of change in blood cell shapes in certain parts of the world.

ACTIVITY MATERIALS

Prepared slides showing Sickle cells
Microscopes
Slides and cover slips
Fresh or prepared slides of normal blood cells
Living Guppies
Cotton (absorbent)

WHAT TO DO

Prepare a fish so that you can observe blood flowing through its capillaries. Observe the flow of blood. What happens when the red blood cells pass through the smallest part of a capillary? How do the cells change shape after passing through the most constricted part of the capillary? Would you describe the cells as flexible or inflexible?

Recall one of the functions of red blood cells. Would you expect red blood cells in other vertebrate animals, including man, to behave in much the same manner as those of the fish?

Sketch a few cells from prepared slides of normal and sickle cells.

In sickle-cell anemia the red blood cells are normal in shape until they give up their oxygen to the body tissues. Some of them may become sickled. These sickled cells are destroyed in the spleen, and anemia then results from too few red blood cells. In what part of the circulatory system do red blood cells give up their oxygen? The sickle cells are relatively inflexible. Would you expect these cells to pass through the smallest capillaries as readily as the normal cells? If some of the sickled cells are ruptured in passing through the capillaries, how might this affect the supply of oxygen to the tissues? If some of the sickled cells rupture, would the result be much the same as if the capillaries were partially plugged?

Red blood cells contain hemoglobin. Hemoglobin unites readily with oxygen as red blood cells pass through the capillaries of the lungs. The red blood cells with their supply of oxygen are then sent to all the body tissues. In persons with sickle-cell anemia the hemoglobin molecule is somewhat different in its structure from the hemoglobin molecule in persons with normal red blood cells. In general terms, what hereditary element seems to control the biochemistry of living things?

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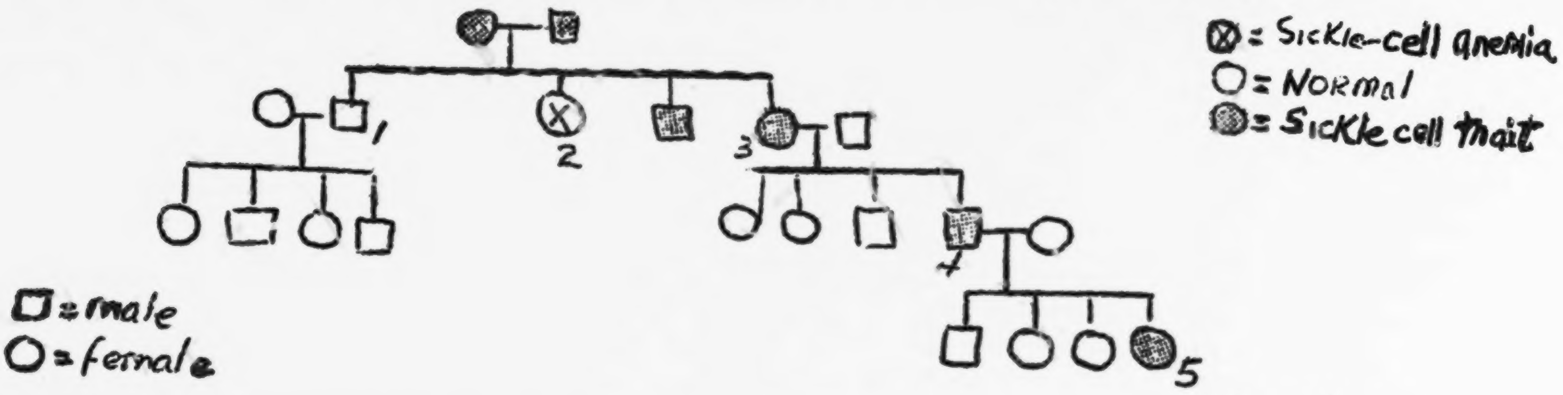
From what you already know of living things do you think it reasonable that this hereditary element might influence the chemical structure of hemoglobin?



Does this pedigree tend to confirm your answer to question just asked above? How many phenotypes are there in the family? If the condition is genetically controlled, how many genotypes might you expect?

Normal and sickle hemoglobin are genetically controlled. Normal hemoglobin is dependent upon a recessive gene (s). In the pedigree shown above, what is the genotype of person no. 1?

Recall that individual no. 2 has very severe sickling and that people with such severe sickling usually die in infancy or childhood. Would you expect person no. 2 to have genotype SS or Ss? Individual no. 3? Individual no. 4? If individual no. 5 marries a person with a genotype like her own, what percentage of their children would you expect to have sickle-cell anemia? Sickle cell trait? Normal red blood cells?

In certain African tribes of Negroes the sickle-cell trait may be found in as much as 40% of the tribe. The gene is not ordinarily found in white populations. How many genes for sickling are lost from the population when a child with sickle-cell anemia dies? If 4/10 of the adult population is herterozygous, the chance of heterozygote mating with a heterozygote is 4/10 X 4/10. Thus, 16/100 = 4/25, or almost 1/5 of the matings would involve two heterozygotes. What fraction of the offspring of such matings would be homozygous for the sickle gene? Would you expect individuals with sickle-cell trait to leave, on the average, more or fewer descendants than those with normal red blood cells? Would this result increase, reduce, or have no effect upon the total number of genes for sickling in the population?

There is no evidence that the frequency of the gene for sickling is being reduced in the African populations. The question now arises, how can gene for sickling be maintained at such a high level while being selected against so strongly?

Scientists have considered at least three hypotheses to account for the commonness of sickle hemoglobin. One involves the mutation rate of a gene. The second pertains to differences in fertility. The third involves susceptibility and resistance to disease. Try to explain with these three clues why sickle-cell trait persists in populations.

It has been estimated by statistical techniques that the mutation rate necessary to replace the genes lost by selection would be about one hundred times the known rate for other human genes. There is no direct evidence of such a high rate. Does this information support or weaken the first hypothesis?

Present available evidence indicates that individuals with the sickle-cell trait do not produce more children than do nonsicklers. Is the second hypothesis weakened or supported?

The hypothesis that individuals with sickle-cell trait are more resistant to disease and hence leave more descendants is a bit more difficult to investigate. As data on sickling were collected and the evidence of the trait was plotted on maps, it became clear that the gene was most common in a belt extending across the central portion of Africa. Malaria and hookworm are diseases that are very common in this region. Find out the symptoms of these diseases and how they are transmitted and also how the symptoms are produced.

If you will remember that the individuals with sickle-cell trait have hemoglobin that differs from normal hemoglobin, how might the sickle-cell trait logically influence which one of the diseases mentioned above?

One investigator examined the blood of 290 children in an East African tribe where both malaria and sickling were common. The results are shown below in table:

	With Malaria	Without Malaria	Total
Sicklers	12 (27.9%)	31 (72.1%)	43
Normal	113 (45.7%)	134 (54.3%)	247

Do these data tend to support the hypothesis?

In order to test this hypothesis directly, thirty volunteers were inoculated with malaria parasites. The volunteers were adult males of approximately the same age and physical condition. A blood examination showed that none of the thirty had malarial parasites at the beginning of the experiment. Fifteen of the group had the sickle-cell trait and fifteen had normal red blood cells. Two of the sicklers and fourteen of the nonsicklers developed malaria. When observations were completed, the individuals that developed malaria were given prolonged treatment to cure the disease. Do these results tend to support the hypothesis developed in questions above?

Do the above observations show that, under certain conditions, the hybrid has a selective advantage over either homozygote?

Do observations indicate that a harmful mutant gene is necessarily harmful under all conditions?

Can a gene harmful under certain conditions be beneficial to a population under other conditions?

Do observations provide a clear example of inherited resistance to disease due to a single gene?

The incidence of sickle-cell trait in the early American Negro population (whose ancestors, of course, were African) is estimated at about 22%. Would mixture with white population cause this frequency to increase, decrease, or remain the same?

In this country man has virtually eliminated Anopheles, the malaria-carrying mosquito. Under these conditions, would the heterozygote have a survival advantage? Recall that the individual homozygous for sickling usually dies before reaching reproductive age. What will tend to happen to the frequency of the gene for sickling?

The incidence of sickle-cell trait in the present American Negro population is about 9%. This change in gene frequency is a clear example of what biological principle? Has any evidence been presented in this exercise that indicates that a person heterozygous for the sickle gene is unlikely to become a capable scientist? physician? business man? What generalization can you draw from these last questions and your answers?

COMPARISON OF FORM TO SHOW CHANGE

PURPOSE

To learn that the historical development of a group of living things may be studied through change of a single characteristic within that group and by comparisons of the changes that have taken place.

ACTIVITY MATERIALS

Ditto material of information below
Graph paper
Colored pencils

WHAT TO DO

Ditto information given below

The characteristic to be described is the span of the cheek teeth from the second premolar to and including the third molar. (See figure 1)

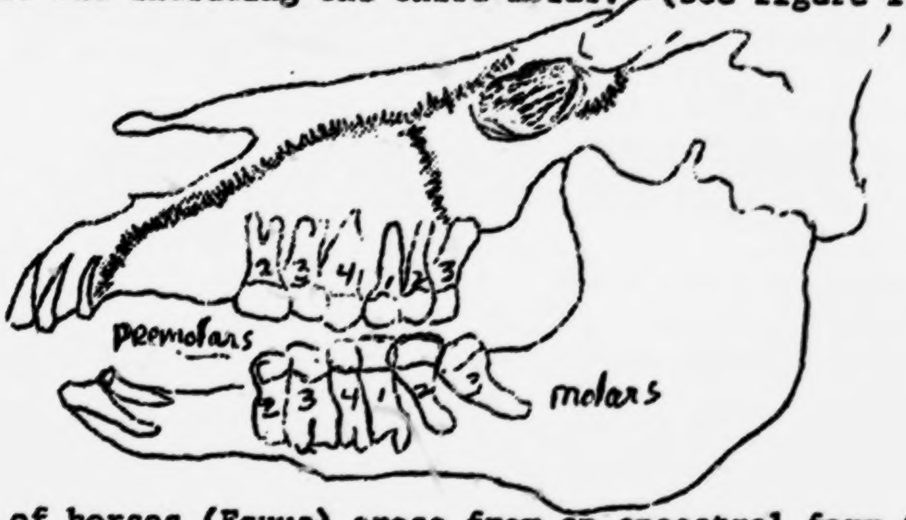


FIGURE 1

The modern genus of horses (Equus) arose from an ancestral form (Hyracotherium) which first appeared about 45 million years ago during the Eocene period and had its major evolutionary center in North America. During this period 17 genera of horses evolved in North America; of these only Equus is still living and this genus was reintroduced to the United States from Europe, having become extinct in North America about 10 thousand years ago. The probable developmental sequence of these genera is shown in Figure 2.

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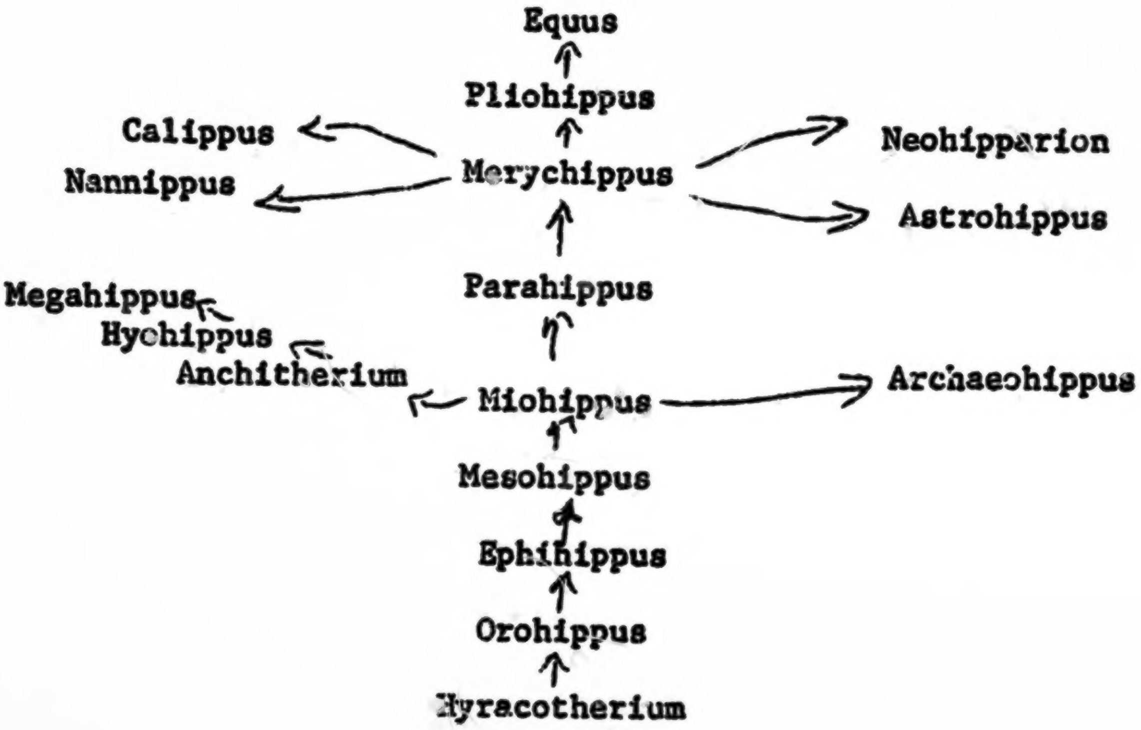
Figure 2


Equus
Pliohippus
Calippus
Nannippus
Merychippus
Neohipparion
Astrohippus
Parahippus
Megahippus
Hychippus
Anchitherium
Miohippus
Archaeohippus
Mesohippus
Ephihippus
Orohippus
Hyracotherium

Note that in this developmental sequence Hyracotherium evolved to seven terminal genera.
Consider now the change that has occurred in the span of the cheek teeth in this developmental sequence. Table shown in figure 3 presents the essential data: the 17 genera of horses, the time at which each existed, and the average span of cheek teeth of each genus in each age.

Prepare a graphic representation of these data by completing figure 4. Plot as a point on the graph tooth span versus age at which a genus existed for each genus. Identify each point by recording the genus identification number (see figure 3) near each point.

Now indicate the developmental change in span of cheek teeth by connecting the points with lightly drawn solid lines as suggested by relationships in figure 2.

Examine only the following three developmental lines: 1. Hyracotherium to Megahippus 2. Hyracotherium to Equus 3. Hyracotherium to Archaeohippus. Draw heavy, smooth curves on figure 4 to represent the general trend in teeth size in each of these three lines.

Using the graph which you have prepared in figure 4, answer the following questions. What general trend seems to characterize the evolutionary change in span of cheek teeth?
Fill in the blanks in the following chart (figure 5).

Figure 3

Genera of the Equidae	Date of Existence	Span of Cheek Teeth in Centimeters
1. Hyracotherium	Early Eocene	4.3
2. Orohippus	Middle Eocene	4.3
3. Ephihippus	Late Eocene	4.7
4. Mesohippus	Early Oligocene	7.2
	Middle Oligocene	7.3
5. Miohippus	Late Oligocene	8.4
	Early Miocene	8.3
6. Parahippus	Early Miocene	10.0
	Middle Miocene	12.4
7. Anchitherium	Early Miocene	11.3
8. Archaeophippus	Middle Miocene	6.5
9. Merychippus	Middle Miocene	10.2
	Late Miocene	12.5
	Early Pleiocene	12.6
10. Hypohippus	Late Miocene	14.2
11. Megahippus	Early Pleiocene	21.5
12. Pliohippus	Early Pleiocene	15.5
	Middle Pleiocene	15.6
13. Nannippus	Early Pleiocene	11.0
	Late Pleiocene	10.7
14. Calippus	Early Pleiocene	9.3
15. Neohipparion	Middle Pleiocene	13.1
16. Astrohippus	Middle Pleiocene	11.8
	Late Pleiocene	11.8
17. Equus	Late Pleiocene	18.8
	Pleistocene	17.6

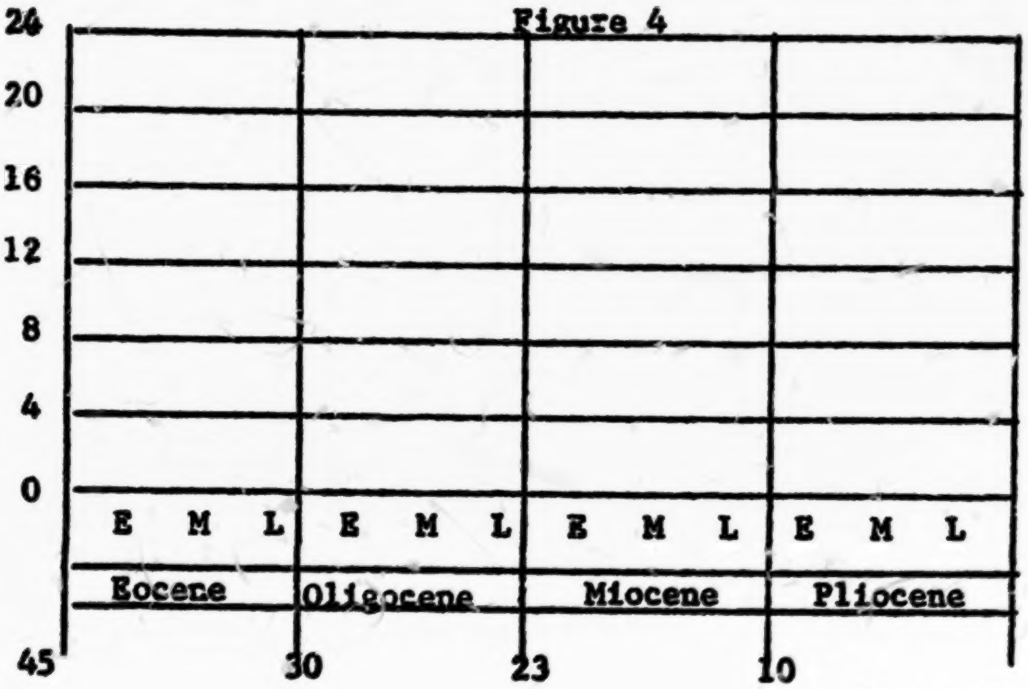


Figure 4

Developmental line	Total change in tooth span in cm	Average change in tooth span in cm per million years
a) Hyracotherium to Megahippus		
b) Hyracotherium to Equus		
c) Hyracotherium to Achaeohippus		

Figure 5

Why might it be concluded that the development of one character in one developmental line can change markedly even though the general direction of evolution of the character remains the same?

What is the evidence that, in the development of the horse, some lines may evolve faster and/or slower than the normal rate of evolution?

Why could one assume that a characteristic once gained can be again lost (regressive evolution)?

UNIT FOUR: CHANGE AND CONTINUITY OF LIFE

HOW FOSSILS ARE FORMED

PURPOSE

To illustrate various methods of how animals and plants have been preserved over the centuries.

ACTIVITY MATERIALS

Fossil specimens (a student collection or science department collection)

Ice cube	Plaster of Paris
Duco cement	Clay (modeling)

WHAT TO DO

Students work in teams and make preparations of poster material to show the location of fossils in geologic formations.

Students display real fossils in the proper geological formation.

Prepare a fly or a toy animal in an ice cube tray. Freeze in freezer. Give an explanation of how prehistoric animals were preserved by ice.

Prepare an insect by placing a drop of Duco cement over the dead fly. Allow this to harden. Give an explanation of how insects were preserved in amber. Encourage students to bring in any insects that may be preserved in amber beads.

Students prepare a plaster cast of a leaf print. (see figure 1). Prepare a base of modeling clay as shown in the figure. Place a leaf on this base. Place plaster of Paris on top of this. When the plaster of Paris hardens, remove and the result will be a "fossil" imprint.

Figure 1